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2016 Annual Groundwater Monitoring Report

Palermo Wellfield Superfund Site
Tumwater, Washington

for

Washington State Department of Transportation

April 21, 2017

GeoEngineers

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Earth Science + Technology

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1.0 INTRODUCTION

This draft annual report was prepared to summarize 2016 long-term groundwater monitoring results at the Palermo Wellfield Superfund Site (Site), U.S. Environmental Protection Agency (EPA) ID: WA 0000026534, located in Tumwater, Washington (Figure 1). This annual groundwater monitoring report was prepared for the Washington State Department of Transportation (WSDOT) in accordance with the requirements described in the Administrative Settlement Agreement and Order on Consent for Response Actions (ASAOC) Statement of Work (SOW), CERCLA Docket 10-2012-0149, entered into by EPA and WSDOT, effective July 6, 2012 (EPA 2012).

1.1. Background

During routine sampling in 1993, trichloroethene (TCE) was detected in groundwater samples from three City of Tumwater (City) municipal water supply wells (TW-2, TW-4 and TW-5) at the Palermo Wellfield (Wellfield) (Figure 1). TCE was detected at a concentration exceeding the EPA drinking water maximum contaminant level (MCL) of 5 micrograms per liter (µg/L) in groundwater samples from well TW-2 that has since been abandoned.

Environmental explorations and studies have been performed and remedial actions have been implemented on the Site since 1993 by the EPA, City, Washington State Department of Ecology (Ecology), and most recently by WSDOT to evaluate the magnitude and extent of tetrachloroethene or perchloroethylene (PCE) and TCE on the Site and reduce exposure to these chemicals of concern by the public. An elongated area of TCE impacts and a more localized area of PCE impacts in groundwater were identified based on the results of environmental investigations and studies performed following the discovery of TCE in groundwater samples from the Wellfield. Remedial actions performed to date have included a groundwater treatment system installed at the Wellfield, a soil vapor extraction (SVE) treatment system at Southgate Dry Cleaners, and a groundwater subdrain and treatment lagoon system in the Palermo Neighborhood (Neighborhood) (Figure 1). The Wellfield groundwater treatment system and subdrain and treatment lagoon system remain active.

1.2. Groundwater Monitoring

WSDOT has conducted groundwater monitoring since 2013. Before 2013, groundwater monitoring was conducted by EPA as part of the remedy selected for the Site as documented in the Record of Decision (ROD) dated November 16, 1999 (EPA 1999). In 2004, EPA began semiannual groundwater monitoring for PCE and TCE at selected monitoring wells as part of the long-term monitoring program. From 2004 to present, an annual monitoring report has been prepared for groundwater monitoring, wellfield treatment system monitoring, and subdrain and treatment lagoon monitoring.

EPA began operating an air stripping treatment system at the Wellfield in 1999 to remove TCE from groundwater. Operation and maintenance of the groundwater treatment system is the responsibility of the City based on an agreement with EPA. Groundwater samples collected from selected production wells and from the air stripper influent and effluent are summarized in this report.

A subdrain system and treatment lagoon were constructed in 2000 within the Neighborhood. The purpose of the subdrain system is to lower the local groundwater table beneath homes west of SE Rainier Avenue and remove PCE and TCE from the collected water (Figure 2). The subdrain system includes a subgrade perforated piping network installed behind the seven southern-most houses west of SE Rainier Avenue. The main perforated pipe or "trunk drain" is beneath the backyards of the houses. Groundwater that enters the perforated pipe flows to an unperforated "tightline" pipe beneath SE Rainier Avenue and M Street SE. The tightline pipe drains to a treatment lagoon located at the Municipal Golf Course. PCE and TCE are removed from the water by surface aeration before being discharged northward to the Deschutes River by way of an existing water course.

Following construction of the subdrain and treatment lagoon and verification of its performance, a maintenance program was established and implemented by Ecology. Ecology monitored the subdrain and lagoon system between 2002 and 2008. EPA conducted performance monitoring of the subdrain and treatment lagoon system from 2009 to 2012, and WSDOT has been performing subdrain and lagoon monitoring beginning in 2013 under terms of the 2012 ASAOC.

Subdrain monitoring and performance data including analytical results, flow volume, and sediment accumulation are summarized and presented in this report.

2.0 SCOPE OF WORK

This draft annual report presents the summary and analysis of data collected from groundwater sampling events conducted in Spring (April) and Fall (September) 2016, and includes trend data, unusual conditions, and a discussion of the capture zone. This draft annual report also includes a summary of operation and maintenance activities pertaining to the subdrain and treatment lagoon system. These activities were generally completed for the 2016 monitoring events using procedures presented in the following documents:

- *Field Sampling and Analysis Plan (FSP) – Semiannual Groundwater Monitoring, Palermo Wellfield Superfund Site (FSP)* (GeoEngineers 2013a).
- *Operation and Maintenance Manual Subdrain System* and *Treatment Lagoon Palermo Wellfield Superfund Site (O&M Manual) (*URSG 2002*).*
- *Addendum 1 Operation and Maintenance Manual Subdrain System and Treatment Lagoon, Palermo Wellfield Superfund Site* (GeoEngineers 2013b).
- *Addendum 2 Operation and Maintenance Manual Subdrain System and Treatment Lagoon, Palermo Wellfield Superfund Site (*GeoEngineers 2014a*).*

Activities completed during the 2016 monitoring efforts include:

- Collection of groundwater samples and depth to groundwater measurements at 40 monitoring locations during the Spring 2016 monitoring event.
- Collection of groundwater samples and depth to groundwater measurements at 41 monitoring locations during the Fall 2016 monitoring event.
- Collection of water samples from eight subdrain and treatment lagoon locations.

- Measurement of sediment accumulation and discharge rates at 11 subdrain and treatment lagoon locations.
- Submittal of groundwater and water samples for laboratory analyses of PCE, TCE, and other selected Volatile Organic Compounds (VOCs).

3.0 GROUNDWATER

Groundwater monitoring field activities, chemical analytical results, concentration trends, and the Wellfield groundwater capture zone are summarized in this section.

3.1. Field Activities

Field activities performed during the 2016 monitoring events included collecting samples from 29 monitoring wells during the Spring 2016 event and 27 monitoring wells during the Fall 2016 event, 11 shallow piezometers during both the Spring/Fall 2106 events, and three locations at the Wellfield during the Fall 2016 event. Attributes of monitoring locations are presented in Table 1 and groundwater depths and elevations from the Spring and Fall 2016 sampling events are presented in Table 2 and Figures 3 and 4. Field forms associated with the sampling are provided in Appendix A. Groundwater samples for chemical analysis were submitted to Onsite Environmental Inc. analytical laboratory (lab) in Redmond, Washington, using the chain-of-custody procedures presented in the FSP. Specific details about the monitoring locations are described below. Deviations from the FSP are outlined in Section 3.1.3.

3.1.1. *Monitoring Wells and Piezometers*

Groundwater from monitoring wells and piezometers was sampled using methodology described in the FSP (GeoEngineers 2013a). Samples were generally collected using a portable Grundfos submersible pump at monitoring wells with the exception of monitoring wells MW-93-02 and MW-96-17 that were sampled using a peristaltic pump and an internal hand pump, respectively. Field parameter measurements were recorded using a multi-parameter water quality meter and a turbidimeter.

Groundwater samples from piezometers in the Neighborhood were collected in accordance with the FSP using a peristaltic pump after field parameter stabilization.

3.1.2. *Wellfield Monitoring Locations*

Production wells TW-4 and TW-8, and stripper tower ST-2 were sampled at the Wellfield during Fall 2016 only because the wellfield was offline for upgrades during the Spring 2016 monitoring event. Consistent with the FSP, no field parameters were measured for the groundwater samples that were collected. Production well TW-16, which was not connected to the treatment system, was also not sampled during both events. TW-16, and the remaining active production wells, were placed back online by the City in mid-September after the Fall 2016 monitoring event occurred.

3.1.3. *Deviations from the Groundwater Monitoring FSP*

The list outlined below is specific to deviations from the FSP which occurred during 2016.

- For both monitoring events, MW-96-17 and MW-93-02 were not sampled with a submersible pump. Monitoring well MW-96-17 was sampled using a permanent internal down-hole pump maintained by the City. A peristaltic pump was used to collect the sample from MW-93-02 because an obstruction (stick) was present in the well casing. The stick was partially removed from the casing by the City during the Fall 2013 monitoring event, but could not be completely extracted.

- The City wells MW-96-15 and MW-96-16 contain a different brand of submersible pump (QED Micropurge pump) which is not compatible with the Grundfos submersible pump system. These pumps were removed before sample collection and then replaced after sampling was completed for both the Spring and Fall monitoring events.
- Stripper Tower 1 (ST-1) was not sampled during either monitoring event in 2016 because it was not operating. Stripper Tower 2 was sampled only during the Fall monitoring event, because ST-2 was not operating during the Spring event.
- Production well TW-5 was not sampled during 2016 because it was decommissioned in January 2014. Monitoring at this location has been discontinued.
- No groundwater samples were collected from production well TW-16 which was previously approved by EPA. TW-16 was not operating during either 2016 sampling events.
- Monitoring well MW-ES-08 was not sampled in 2016, because it is now located within Lake Park Drive SW as a result of land development nearby. Collecting samples at MW-ES-08 would require a partial lane closure and traffic control. Groundwater monitoring at this location has been temporarily discontinued based on discussions with EPA (Zavala 2014).
- Monitoring at four seeps (SEEP-1 through SEEP-3, and SEEP-5) and three piezometers at the base of the bluff (PZ-704, PZ-709, and PZ-715) was discontinued in Summer 2014 based on discussions with EPA (Zavala 2014).
- Water level measurements and groundwater samples were not collected at monitoring wells MW-ES-03 and MW-ES-04 as part of the Fall 2016 event because an updated consent for property access agreement was being negotiated during the sample collection and permission was not given to enter the property.
- The Barnes Lake water level was measured at the staff gauge in the southeast portion of the lake (Table 2). The gauge is located northeast of the current WSDOT Materials Testing Laboratory and is maintained by the City.

3.2. Groundwater Monitoring Analytical Results

This section describes the results of the laboratory analyses completed for the Spring and Fall 2016 sampling events including a data quality assessment, comparison to ROD cleanup goals, and a brief description of the analytical results. PCE and TCE concentrations are presented on Table 2 and visually illustrated on Figure 5. Tabulated analytical data are included in Appendix B. Data validation reports are presented in Appendix C. Laboratory analytical reports are presented in Appendix D.

3.2.1. *Data Quality Assessment*

Data quality for Spring and Fall 2016 semiannual groundwater monitoring events was found to be acceptable as reported. Detailed assessments are provided in the data validation reports, Appendix C.

3.2.2. *Groundwater Record of Decision Cleanup Goals*

Site groundwater chemicals of concern identified in the ROD are PCE and TCE (EPA 1999). Analytical results discussed below were compared to the ROD remediation goals (RGs) for these chemicals. ROD RGs for PCE and TCE are both 5 µg/L, the maximum contaminant level (MCL) for drinking water as referenced in the Federal Clean Water Act.

3.2.3. *Monitoring Wells and Piezometers*

PCE and TCE are the primary VOCs detected in groundwater, which is consistent with historical sampling results. Both PCE and TCE detected in groundwater exceeded the 5 µg/L RG at some locations (Table 2 and Figure 5).

Concentrations of PCE in 2016 ranged from 0.21 µg/L to 29 µg/L in monitoring wells and piezometers. Concentrations of PCE exceeded the ROD remediation goal of 5 µg/L in groundwater samples from two of 29 monitoring wells during the Spring 2016 monitoring and at one monitoring well during the Fall 2016 monitoring. The maximum concentration of PCE of 29 µg/L was detected in the groundwater sample collected from monitoring well MW-ES-04 during the Spring monitoring event. PCE was not detected at concentrations exceeding the ROD RG of 5 µg/L in groundwater samples from the piezometers.

Concentrations of TCE at monitoring wells and piezometers ranged from 0.22 µg/L to 97 µg/L. Concentrations of TCE exceeded the ROD remediation goal of 5 µg/L in groundwater samples from ten of the 29 monitoring wells in Spring, eleven of the 27 monitoring wells in the Fall, and three out of 11 piezometers during both monitoring events in 2016. The maximum concentration of TCE of 97 µg/L was detected in the groundwater sample collected from MW-ES-09 during the Fall monitoring event. TCE was detected at concentrations that exceed the ROD RG in groundwater samples from piezometers PZ-720, PZ-721 and PZ-724 located near the intersection of SE Rainier Avenue and SE N Street.

Cis-1,2-dichloroethene (cis-1,2-DCE) was detected in groundwater samples from the following monitoring wells or piezometers:

- MW-UI at 0.24 µg/L (Spring)
- PZ-721 at 0.26 µg/L (Spring) and 0.78 µg/L (Fall)
- PZ-724 at 0.26 µg/L (Spring) and 0.66 µg/L (Fall)
- PZ-728 at 0.22 µg/L (Spring)
- MW-ES-09 at 0.52 µg/L (Fall)

Additional compounds analyzed for including 1,1-dichloroethene, trans-1,2-dichloroethene, and vinyl chloride were not detected in groundwater samples from monitoring wells or piezometers during the 2016 monitoring events.

3.2.4. *Wellfield*

TCE was detected at one of the two active production wells sampled during the Spring 2016 sampling event. The Spring TCE concentration in the groundwater sample from production well TW-4 (0.6 µg/L) was below the ROD remediation goal of 5 µg/L before treatment through the air stripper.

PCE and TCE were not detected in the effluent sample collected from Stripper Tower ST-2 during the Spring monitoring event. No additional compounds were detected in samples collected from the Wellfield in 2016. Samples could not be collected from stripper tower ST-1 or production well TW-16 during either monitoring event because they were not operating. Similarly, a sample was not collected from Stripper Tower ST-2 during the Spring because the tower was not operating.

3.3. Mann-Kendall Trend Test

The Mann-Kendall trend test was used to evaluate changes in PCE and TCE concentrations at monitoring locations on the Site over time. Trend test results are presented in Table 3 for monitoring locations where PCE or TCE were detected. The Mann-Kendall trend test was performed using groundwater monitoring data collected since 2004 when long-term monitoring began at the Site using the EPA software package ProUCL (Version 5.0.00), using a 95 percent confidence limit. Concentrations of PCE did not demonstrate a statistically significant increasing trend at any of the monitoring locations using the Mann-Kendall trend test. The trend test does indicate a statistically significant decreasing trend in concentrations of PCE at seven monitoring wells and two piezometers. Concentrations of TCE demonstrate a statistically significant increasing trend at PZ-719, PZ-726, and RPZ-731. The trend test indicates a statistically significant decreasing trend in concentrations of TCE at 14 monitoring wells, two piezometers, and production well TW-4. Basic trend plots have been provided in Appendix E for comparison.

3.4. Target Groundwater Capture Zone

A preliminary capture zone analysis was performed and included in the *Draft Revised Summary of Existing Information Report* (GeoEngineers 2014b). The preliminary capture zone analysis is included in Appendix F.

The City is undergoing an expansion program to increase production at the Wellfield. The Wellfield has not continually operated during this expansion program and only operates as a backup when public demand requires the need to produce enough drinking water for the City. Based on our current understanding of Wellfield operations, three of the original six production wells (TW-4, TW-6 and TW-8) that were evaluated as part of the remedy remain active and periodically produces water for public consumption. The City has decommissioned two of the production wells (TW-2 and TW-5) while a third (TW-3) remains inactive and awaits further assessment. The City installed one new production well (TW-16) in 2012 and another production well (TW-17) in 2014. Groundwater from production well TW-16 was first analyzed in 2012 and contained TCE at a concentration of 19.5 µg/L, greater than the ROD RG of 5 µg/L. Groundwater samples have been collected from production well TW-16 semiannually since Spring 2014. Results from these analyses are summarized in Section 3.2.4 and Table 2. PCE and TCE were not detected in a sample collected from production well TW-17 collected in January 2014. We understand the City will be bringing both TW-16 and TW-17 into use in the near future and plans to provide a connection to the treatment system for both TW-16 and TW-17 in early 2016 to increase production of the Wellfield.

The Wellfield and treatment system were identified by EPA as key components of the site remedy (EPA 1999). Changes to the Wellfield that may impact the capture zone analysis will continue to be presented in annual groundwater monitoring reports.

3.5. Conclusions

Groundwater flow direction in the uppermost, unconfined aquifer at the Site flows generally east-northeast and is consistent with previous monitoring events. The groundwater elevation was lower during the Fall monitoring event at each location, which is likely attributed to warm weather/less precipitation during the Summer.

PCE has been detected in groundwater samples at concentrations exceeding the ROD RG of 5 µg/L from two monitoring wells (MW-ES-04 and MW-ES-06) located in and east of the Southgate Shopping Center on Capitol Boulevard. These wells monitor groundwater approximately 50 feet below ground surface (Table 1). PCE was not detected at concentrations exceeding the ROD RG in groundwater samples from monitoring locations throughout the remainder of the Site.

TCE has been detected in a more widespread area throughout the Site. TCE has been detected in groundwater samples at concentrations exceeding the ROD RG of 5 µg/L in groundwater samples from seven to eight monitoring wells and three piezometers (Table 2 and Figure 5), at depths ranging from less than 5 feet below ground surface to more than 100 feet below ground surface. The highest concentrations of TCE (up to 97 µg/L during the Fall monitoring event) were detected in groundwater samples from monitoring well MW-ES-09 within the Neighborhood. Groundwater samples with PCE concentrations that exceeded five times the ROD RG in groundwater were collected from monitoring locations in and east of the Southgate Shopping Center on Capitol Boulevard and in the Neighborhood.

Concentrations of PCE and TCE in groundwater samples collected in 2016 are generally consistent with the previous monitoring events in 2013 through 2015. With one exception, concentration trends for PCE and TCE are either decreasing or stable based on Mann-Kendall trend tests performed on data obtained since 2004. The TCE concentration trend in groundwater samples from piezometers PZ-719, PZ-726, and RPZ-731 showed an increasing trend; however, the concentrations remain below the ROD RG of 5 µg/L. This increasing trend was not observed in 2013 through 2015. A discussion of the Mann-Kendall trend test is presented in Section 3.3.

Groundwater production at the Wellfield was lower than is typical because new production wells TW-16 and TW-17, installed in 2012 and 2014 respectively, had not been connected to the Wellfield treatment and distribution system by the time the Fall 2016 monitoring event occurred. It is anticipated that the capture zone analysis will be revised after the collection of additional field data during supplemental data gaps investigation activities and the incorporation of available new Wellfield pumping data.

4.0 SUBDRAIN AND TREATMENT LAGOON

The purpose of the subdrain and lagoon system is to lower the groundwater depth beneath the Neighborhood homes west of SE Rainier Avenue to at least 18 inches (1.5 feet) below the bottom of the crawlspaces or 3 feet below ground surface (URSG 2002). This increase in groundwater depth aims at reducing the risk of vapor intrusion into the homes from shallow groundwater containing PCE and TCE. Shallow groundwater collected in the subdrain is conveyed via a tightline pipe and treated via surface aeration at the treatment lagoon before it leaves the lagoon (Figure 2). The following sections describe the field activities, results and conclusions for the subdrain and treatment lagoon performance monitoring.

4.1. Field Activities

Field activities performed during the two 2016 monitoring events were generally similar. Lagoon depth measurements were collected during the Fall 2016 monitoring event.

4.1.1. *Subdrain and Tightline*

The subsurface subdrain located behind the seven southern-most Neighborhood houses on the western side of Rainier Avenue SE collects shallow groundwater though an underground perforated pipe and conveys the water to the treatment lagoon through a solid tightline pipe beneath M Street SE. This section describes performance monitoring for this portion of the remedy and includes sampling, water elevation monitoring, discharge rate measurements and sediment accumulation monitoring.

4.1.1.1. SAMPLING

Subdrain cleanout samples were collected using a polyethylene dipper by lowering the cup portion into each of the cleanouts, placing it under the outfalls, or by submerging it into the water. Samples were submitted to the analytical laboratory using the same chain-of-custody procedures and analytical methods using during groundwater monitoring.

4.1.1.2. WATER ELEVATION MONITORING

Depth to water was measured in the Neighborhood piezometers, the subdrain cleanouts and the tightline catch basins using an electronic water level indicator. The measurements were used to calculate groundwater elevations in the Neighborhood (Table 2 and Figures 6 and 7).

4.1.1.3. WATER FLOW RATE MEASUREMENTS

Flow rate was measured using a Global Flow Meter as outlined in the primary Site O&M Manual (URSG 2002). Discharge was calculated to equate to gallons per minute (gpm). Figure 8 and Table 5 show the discharge volumes encountered in the subdrain.

4.1.1.4. SEDIMENT ACCUMULATION MONITORING

Total depth measurements were collected using an incrementally marked measuring rod placed inside of each subdrain cleanout and tightline catch basin to assess the sediment accumulated in the subdrain cleanouts and tightline catch basins. Table 6 summarizes the estimated depth of sediment in these structures in comparison to the original surveyed structure bottom.

4.1.2. *Treatment Lagoon*

Treatment lagoon performance is measured semiannually with respect to sampling and flow rate and once a year for sediment accumulation. Semiannual monitoring occurs at multiple lagoon inflows, treatment lagoon effluent and a compliance point at the Deschutes River, whereas sediment accumulation monitoring occurs on an annual basis at the treatment lagoon.

4.1.2.1. INFLOWS TO LAGOON

The treatment lagoon receives water from four monitored sources:

- Station 350 – M Street Storm Drain Outfall
- Station 356 – Upstream Watercourse Inflow from the Wetlands
- Station 360 – Subdrain Tightline Outfall to Treatment Lagoon
- Station 362 – M Street Terminus Catch Basin Outfall

These locations were monitored using the Global Flow Probe, an incrementally marked tape measure, and dipper for sample collection. The flow probe was used to measure flow rate by placing the probe at the outfall entrance and recording the flow rate. The water level in each outfall was measured using the tape measure. Table 5 summarizes the discharge from each of the locations. A sample was also collected from each of the stations (if flowing) by placing the dipper into the discharge.

4.1.2.2. TREATMENT LAGOON EFFLUENT

Treatment lagoon samples were collected using a polyethylene dipper by lowering and submerging the cup portion into the spillway water. Samples were submitted to the same laboratory as the groundwater samples under the same chain of custody procedures and for the same analyses.

The treatment lagoon effluent (Station 361) is monitored while aeration is actively occurring. Because the lagoon spillway is armored with rip rap, discharge is measured at an outfall approximately 800 feet downstream at a pond located north of the Tumwater Athletic Club where a more accurate flow rate can be determined (Table 5).

4.1.2.3. POINT OF COMPLIANCE

The point of compliance (Station 364) is located at the Deschutes River Outfall located approximately 2,000 feet downstream from the treatment lagoon. This location was monitored and sampled using the same equipment and measuring tools described in the preceding sections. Discharge rate for this station also appears in Table 5.

4.1.2.4. SEDIMENT ACCUMULATION MONITORING

Annual sediment accumulation monitoring occurred during the Fall 2016 monitoring event at three transects through the lagoon. The depth to the base of the lagoon is measured at each of these transects from a boat at 2 foot intervals using a rigid, incrementally marked measuring rod and then compared to the original surveyed lagoon depth. Appendix G shows the comparison for the annual monitoring.

4.1.3. *Deviations from the Subdrain and Treatment Lagoon O&M Amendment and QAPP*

The following have been noted as deviations with respect to the Subdrain and Treatment Lagoon O&M Amendment and QAPP:

- Flow rate at Station 356 was not obtained during the Spring and Fall 2016 monitoring period because this area upstream of the lagoon has become wide and slow and could not be accessed safely.
- Flow rates and samples were not collected at Station 362 for both Spring and Fall 2016 because no water was present at this location. This is not an uncommon occurrence for this outfall.

4.2. Subdrain and Treatment Lagoon Monitoring Analytical Results

This section describes the results of the laboratory analysis completed for the Spring and Fall 2016 sampling events. Table 2 and Figure 5 summarize PCE and TCE concentrations in groundwater samples collected from piezometers surrounding the subdrain, the subdrain itself and treatment lagoon locations. The data validation reports are presented in Appendix C. Laboratory analytical reports are presented in Appendix D.

4.2.1. *Data Quality Assessment*

Data quality for both the Spring and Fall 2016 semiannual O&M monitoring was found to be acceptable. A detailed assessment is provided in the data validation reports in Appendix C.

4.2.2. *Piezometers*

The piezometers of interest relative to the subdrain are located near the bluff and in SE Rainier Avenue. PCE was detected in groundwater at concentrations less than the ROD RG of 5 µg/L at piezometers PZ-720 and RPZ-732 during the Spring 2016 monitoring event and at PZ-720, PZ-721, and RPZ-732 during the Fall event (Table 2). TCE was detected in groundwater samples from piezometers PZ-719, PZ-720 and PZ-721 in SE Rainier Avenue. Concentrations of TCE at PZ-720 and PZ-721 equaled or exceeded the ROD RG for groundwater during both semiannual events and ranged from 9.9 to 37 µg/L. Higher concentrations of TCE occurred during the Fall. Additional details on analytical results for the Neighborhood piezometers are presented in Section 3.2.3.

4.2.3. *Subdrain Cleanouts*

PCE and TCE were detected in water samples from the three subdrain cleanouts along SE Rainier Avenue sampled during 2016. Concentrations of PCE ranged from 4 to 11 µg/L and concentrations of TCE ranged from 6 to 14 µg/L. The highest concentrations of PCE were detected in samples from Cleanout CO-6. The highest concentrations of TCE were detected in samples from Cleanout CO-4 (Figure 8).

4.2.4. *Treatment Lagoon*

Monitoring locations for the treatment lagoon are discussed by location including inflows, effluent and point of compliance.

4.2.4.1. RECORD OF DECISION SURFACE WATER DISCHARGE CLEANUP GOALS

Surface water discharge cleanup goals are based on the remedial action objective for groundwater ponding as surface water in Neighborhood backyards. The objective is to prevent discharge of groundwater containing PCE and TCE in excess of the surface water RG to the Deschutes River. Remediation goals at the point of compliance (Deschutes River) are 0.8 µg/L for PCE and 2.7 µg/L for TCE.

4.2.4.2. INFLOWS

Inflow sample testing results for the treatment lagoon are briefly summarized by location below and in Table 5.

- **Station 350 – M Street Storm Drain Outfall:** PCE was not detected at concentrations greater than the detection limit. TCE was detected during Spring and Fall at 1.5 µg/L or less.
- **Station 356 – Upstream Watercourse from Wetlands:** PCE and TCE were not detected during either monitoring event.
- **Station 360 – Subdrain Tightline Outfall:** PCE and TCE were detected during both monitoring events. PCE was detected at similar concentrations of 4.1 and 3.3 µg/L between Spring and Fall, respectively. TCE was detected at a concentration of 9.6 µg/L for both Spring and Fall 2016 monitoring events.
- **Station 362 – M Street Terminus Catch Basin Outfall:** Samples were not collected because there was not flow during both Spring and Fall.

4.2.4.3. LAGOON EFFLUENT

PCE concentrations of 0.26 µg/L (Spring) and 0.2 µg/L (Fall) in lagoon effluent samples collected post-aeration were slightly greater than the PCE reporting limit during both sampling events. TCE concentrations were 0.73 µg/L in the Spring and 0.66 µg/L in the Fall.

4.2.4.4. POINT OF COMPLIANCE

At the downstream point of compliance located at the Deschutes River, TCE was detected at a concentration of 0.41 µg/L in the Spring and 0.42 µg/L during the Fall monitoring. PCE was not detected during either monitoring event in 2016.

4.3. Subdrain and Treatment Lagoon Monitoring Conclusions

To better discuss observations and results, the conclusions have been grouped together by monitoring element such that piezometers, subdrain, tightline, treatment lagoon and effluent and point of compliance are discussed separately.

4.3.1. *Piezometers*

Water level elevations at the piezometers in SE Rainier Avenue were used to measure reduction in groundwater elevation to determine compliance with the O&M Plan. Groundwater depth in the piezometers in SE Rainier Avenue ranged from more than one foot above ground surface (artesian) near the south end of the subdrain (PZ-722) to more than 3 feet below ground surface in piezometer PZ-720, near the north end of the subdrain. A reduction in water table surface elevation to 1.5 feet below the bottom of the crawlspaces (or 3 feet below ground surface) was not achieved for the southern portion of the subdrain during the Spring monitoring period and likely would be similar for the Fall monitoring using this approach if PZ-722 had not been damaged (Table 7).

Crawlspace depths below ground surface under houses west of SE Rainier Avenue are not uniform based on observations from recent air monitoring in the Neighborhood. In addition, the piezometers used for measuring depth to groundwater are generally located approximately 50 to 100 feet from the nearest crawlspace access. The distance between the subdrain and the nearest crawlspace access is approximately 10 to 20 feet. As shown on Figure 6, groundwater elevations near the subdrain are influenced by the presence of the drain and the elevation of the groundwater entering the drain at the cleanout locations. Using data from both the subdrain and the piezometers, the localized depth to groundwater beneath the seven southern-most homes west of SE Rainier Avenue likely exceeds three feet and meets the performance monitoring criteria.

4.3.2. *Subdrain and Tightline*

This section discusses conclusions relative to the subdrain and tightline and is further divided into discussion on results, discharge rates and sediment accumulation.

4.3.2.1. RESULTS

The highest concentrations of PCE in water samples collected from the subdrain during Fall 2016 were measured at Station 357 (CO-6) and the highest for TCE during the same period was at Station 358 (CO-4). Similar conditions were encountered during the Spring 2016 monitoring.

4.3.2.2. DISCHARGE RATES

Flow volumes ranged from 16 to 4,450 gpm as summarized on Table 5 and general observations relative to each location. Slow flow, soft bottoms and organic matter were encountered at multiple locations during both Spring and Fall monitoring. Because this is a closed system, the discharge from Station 359 at Cleanout CO-1 should be more or less equivalent to the discharge into the treatment lagoon at Station 360. The discrepancy in discharge between the two locations (Station 359 and 360) was observed for both 2016 monitoring events and is consistent with past observations since the subdrain monitoring began in 2002.

4.3.2.3. SEDIMENT ACCUMULATION

Sediment accumulation exceeded the 0.5-foot threshold at cleanouts CO-4, CO-7 and CO-8 during both the Spring and Fall monitoring (Table 6).

4.3.3. *Treatment Lagoon*

Similar to the preceding section, the treatment lagoon has been divided into separate elements for ease in discussion which include the inflows to the lagoon, the effluent, the compliance point and sediment accumulation.

4.3.3.1. INFLOWS TO THE TREATMENT LAGOON

Sediment accumulation at each of the three outfalls was not observed during the 2016 monitoring period and flow does not appear to be hampered by the large grasses surrounding the outfalls. PCE was not detected in the samples from Station 350 or 356 indicating these locations are not contributing sources of PCE to the treatment lagoon. However, TCE was detected in the samples from Station 350 (SE M Street Storm Drain Outfall) at 1.3 µg/L in Spring 2016 and 1.5 µg/L in Fall 2016.

4.3.3.2. TREATMENT LAGOON EFFLUENT

PCE was detected during both Spring and Fall 2016 at Station 361 (lagoon effluent) at a concentration of 0.26 µg/L (Spring) and 0.2 µg/L (Fall). TCE was also detected at 0.73 µg/L and 0.66 µg/L in the treatment lagoon effluent samples collected during the Spring and Fall events, respectively. These results are generally consistent with analytical results from previous monitoring events. The decrease in concentrations of PCE and TCE in water samples from the tightline outfall (Station 360-lagoon influent) and the lagoon effluent (Station 361), indicate most PCE and TCE are being removed by aeration from the water collected in the subdrain.

4.3.3.3. POINT OF COMPLIANCE – DESCHUTES RIVER

Station 364 was added to the monitoring network in 2003 to allow further evaluation of the point of compliance RG at the location where treated water discharges to the Deschutes River. This station is located where the treated water and water from other drainage ways in the area discharge to the Deschutes River, approximately 2,000 feet downstream from the treatment lagoon to the south. PCE and TCE concentrations at Station 364 were either not detected or did not exceed the RG of 0.8 µg/L for PCE and 2.7 µg/L for TCE for the 2016 monitoring period.

Concentrations of PCE and TCE measured at the Deschutes River point of compliance samples were below the ROD RGs, indicating aeration lagoon treatment met the concentration requirements in 2016, as defined in the O&M Manual (URS 2002).

4.3.3.4. SEDIMENT ACCUMULATION

Sediment accumulation measured on the three transects in the treatment lagoon is presented in Appendix G. It should be noted that the last data points (right side of charts) collected for each lagoon transect measuring event may vary due to the lagoon water level observed during the specific monitoring year. Lagoon transect measurement benchmarks were re-established in 2015 because previous benchmarks were not locatable. Surveying services and benchmark installation was performed by Skillings Connolly on June 24, 2015.

When compared to previous sediment accumulation monitoring, the Fall 2016 profile indicates that limited sediment accumulation has occurred in the north and central portions of the lagoon. Sediment has accumulated in the south portion of the lagoon as measured at Transect A-1. The elevation of the base of the lagoon at A-1 overall appears to be approximately 2.5 feet higher than the original lagoon profile from 2001.

5.0 RECOMMENDATIONS

Recommendations for modifications to long-term groundwater monitoring are presented in the Draft Interim Long-Term Monitoring Plan (GeoEngineers 2015).

Because of the damage observed at PZ-722 during the Spring 2016 monitoring event, it is recommended that PZ-722 be replaced as soon as possible. Groundwater levels and analytical data collected at PZ-722 are a part of ongoing subdrain performance evaluation and evaluating potential vapor intrusion risk to indoor air in the Neighborhood. It is anticipated that PZ-722 will be replaced during planned well repair and installation activities in 2017, which are scheduled as part of the supplemental data gaps field investigation.

After the Spring 2016 subdrain sediment accumulation measurements, subdrain cleaning was identified as being needed to maintain appropriate drainage and sediment capture functions. The City was contacted after the Spring 2016 monitoring event and they performed subdrain cleaning activities in August 2016, prior to the Fall 2016 monitoring event.

6.0 REFERENCES

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TABLES

GeoEngineers

Table 1

Well Construction Summary

2016 Annual Groundwater Monitoring Report
Palermo Wellfield Superfund Site
Tumwater, Washington

Well or Piezometer	Well Location Northing	Well Location Easting	Measuring Point (TOC) Elevation	Screen Interval Depth (feet bgs) Top	Screen Interval Depth (feet bgs) Bottom	Geologic Unit of Screen Interval	Approximate Screen Interval Elevation Top	Approximate Screen Interval Elevation Bottom	Notes
Bluff Area									
MW-UI	616967.53	1038149.35	178.82	17.7	27.7	unknown	161.1	151.1	1,2,5
WDOT-MW-1	617640.6	1038502.3	166.94	30.0	39.5	SP–dense to medium dense, olive green, fine sand	136.9	127.4	3,4,5
WDOT-MW-2	617572.9	1038517.9	165.45	30.0	39.5	SP–very dense, olive green to orange, fine to medium sand	135.5	126.0	3,4,5
MW-100	616814.53	1037366.22	177.70	20.0	30.0	SP-medium dense, brown, fine to coarse sand	157.7	147.7	1,2,5
MW-101A	617215.6	1038148.2	176.47	65.0	75.0	SP-loose, gray, fine to medium sand	111.5	101.5	3,4,5
MW-101B	617198.3	1038151.0	176.41	25.0	35.0	SP-loose to medium dense, light brown, fine to medium sand	151.4	141.4	3,4,5
MW-102	617461.6	1038109.5	166.96	16.0	26.0	SP-loose to medium dense, gray, fine to medium sand	151.0	141.0	3,4,5
MW-103	617769.2	1038225.6	163.40	11.0	21.0	SP-loose to medium dense, gray, fine to medium sand	152.4	142.4	3,4,5
MW-104A	617862.7	1039673.3	170.63	119.0	129.0	SP-medium dense to dense, brown, fine sand	51.6	41.6	3,4,5
MW-104B	617868.8	1039667.6	170.52	52.0	62.0	SP-medium dense, brown, fine grained sand	118.5	108.5	3,4,5
MW-109	617312.79	1038552.35	168.89	64.5	74.5	SP-medium dense to dense, brown, fine to coarse sand	104.4	94.4	1,2,5
MW-111	617663.43	1038824.43	165.41	30.0	40.0	SP-medium dense, brown, fine to medium sand	135.4	125.4	1,2,5
MW-ES-02	617664.68	1039666.61	174.65	95.0	105.0	SM-silty sand	79.7	69.7	1,2,5
MW-ES-03	617546.79	1039463.97	175.07	113.0	123.0	SP to SP-SM-sand with silt	62.1	52.1	1,2,5
MW-ES-04	617548.74	1039477.60	175.11	50.0	60.0	SM/ML/SM-silty sand, sandy silt, silty sand	125.1	115.1	1,2,5
MW-ES-05	617517.36	1039178.92	175.05	86.0	96.0	SP-SM-fine sand with silt	89.1	79.1	1,2,5
MW-ES-06	617517.59	1039200.03	173.30	46.0	56.0	SP-SM-sand +/- silt	127.3	117.3	1,2,5
MW-ES-07	617139.20	1037976.58	177.89	25.0	35.0	SP-sand SP-sand with gravel	152.9	142.9	1,2,5
MW-ES-08	617163.60	1037049.22	177.17	25.0	35.0	SP-SM-sand +/- silt	152.2	142.2	1,2,5
MW-ES-11	617571.6	1038487.8	166.25	80.0	90.0	SW, well graded sand	86.3	76.3	3,4,5
MW-96-15	617161.5	1038944.6	168.85	69.0	79.0	medium fine sand	99.9	89.9	3,4,5
MW-96-16	616828.9	1039709.4	179.58	50.5	60.5	fine medium sand	129.1	119.1	3,4,5
MW-96-17	616770.8	1039836.2	179.51	45.5	55.5	fine brown sand	134.0	124.0	3,4,5
Deschutes Valley Area									
MW-4A	617600.7	1040468.7	109.87	100	110	silty sand and gravel	9.9	-0.1	3,4,5
MW-4B	617600.7	1040468.7	109.83	80	90	silty sand	29.8	19.8	3,4,5
MW-ES-09	617769.4	1040014.5	108.29	20	30	SP-poorly graded sand with silty sand interbed	88.3	78.3	3,4,5
MW-ES-10	617780.1	1040014.3	108.21	82	92	unknown (no description)	26.2	16.2	3,4,5
MW-107	617052.39	1041164.92	114.66	25.0	35.0	ML-very hard, moist, gray silt SP-loose to medium dense, brown, medium to coarse sand	89.7	79.7	1,2,5
MW-110	618032.42	1041013.21	101.93	30.0	40.0	SP-loose to medium dense, gray, fine to medium sand	71.9	61.9	1,2,5
MW-93-02	617159.3	1040344.3	112.84	6.0	11.0	fine silty blue sand brown clay	106.8	101.8	3,4,5
PZ-704	618090.0	1039826.6	110.64	5	7.5	fine to coarse sand with cobbles and boulders	105.6	103.1	3,4,5
PZ-709	617880.0	1039819.2	114.67	5	7.5	fine to coarse sand with cobbles and boulders	109.7	107.2	3,4,5
PZ-715	617683.4	1039815.4	117.82	5	7.5	fine to coarse sand with cobbles and boulders	112.8	110.3	3,4,5
PZ-719	618201.2	1040000.0	106.95	7	10	fine to medium sand	100.0	97.0	3,4,5
PZ-720	618026.8	1039993.1	107.55	7	10	fine to medium sand	100.6	97.6	3,4,5
PZ-721	617874.3	1039991.4	108.15	7	10	fine to medium sand	101.2	98.2	3,4,5
PZ-722	617664.8	1039983.7	108.74	7	10	fine to medium sand	101.7	98.7	3,4,5
PZ-723	618244.6	1040200.8	106.22	7	10	fine to medium sand	99.2	96.2	3,4,5
PZ-724	617976.5	1040198.5	106.28	7	10	fine to medium sand	99.3	96.3	3,4,5
PZ-725	617741.8	1040220.5	107.88	7	10	fine to medium sand	100.9	97.9	3,4,5
PZ-726	618186.5	1040452.6	105.23	7	10	fine to medium sand	98.2	95.2	3,4,5
PZ-728	617851.9	1040464.5	105.11	7	10	fine to medium sand	98.1	95.1	3,4,5
RPZ-730	618230.9	1040684.5	103.85	4.13	9.13	log not on file	99.7	94.7	3,4,5
RPZ-731	617984.7	1040739.1	105.18	4.75	9.75	log not on file	100.4	95.4	3,4,5
RPZ-732	617722.2	1040690.6	105.67	4.63	9.63	log not on file	101.0	96.0	3,4,5
Palermo Wellfield									
TW-4	617493.7	1040659.3	108.95	60	90	large gravel and sand	49.0	19.0	3,4,5
TW-8	617398.0	1040445.6	109.93	70	90	medium to coarse sand and gravel	39.9	19.9	3,4,5
TW-16	617596.0	1040717.2	109.43	54	93	sand and gravel	55.4	16.4	3,4,5

Notes:

Well/piezometer screen interval depths were determined by others during previous investigations.

Geologic units for screened intervals were determined by GeoEngineers based on review of logging information by others from previous investigations.

[1] Existing well locations and TOC elevations were obtained from previous explorations (Parametrix 2012, URS 1999 and personal communications with EPA 2013)

[2] Horizontal Datum: NAD83 WA State Plane North.

[3] Survey performed by Skillings Connolly, Inc. in October 2014.

[4] Horizontal Datum: Washington Coordinate System NAD83/11, south zone, based on network RTK GPS ties to WSDOT control points.

[5] Vertical Datum: North American Vertical Datum of 1988 (NAVD 88).

bgs = below ground surface

TOC = top of casing

Table 2

Groundwater Depths and Elevations and PCE and TCE Analytical Results

2016 Annual Groundwater Monitoring Report
Palermo Wellfield Superfund Site
Tumwater, Washington

Location	Measuring Point Elevation (feet NAVD 88)	Spring 2016				Fall 2016			
		Depth-to-Water[1] (feet BTOC)	Groundwater Elevation[2] (feet NAVD 88)	Tetrachloro-ethene (µg/L)	Trichloro-ethene (µg/L)	Depth-to-Water[1] (feet BTOC)	Groundwater Elevation[2] (feet NAVD 88)	Tetrachloro-ethene (µg/L)	Trichloro-ethene (µg/L)
Monitoring Wells									
MW-4A	109.87	4.79	105.08	0.20 U	0.20 U	7.86	102.01	0.20 U	0.20 U
MW-4B	109.83	4.92	104.91	0.20 U	0.20 U	7.88	101.95	0.20 U	0.20 U
MW-93-02	112.84	4.04	108.80	0.20 U	0.20 U	4.26	108.58	0.20 U	0.20 U
MW-96-15	168.85	22.52	146.33	0.20 U	0.20 U	26.48	142.37	0.20 U	0.20 U
MW-96-16	179.58	44.50	135.08	0.20 U	0.20 U	47.87	131.71	0.20 U	0.20 U
MW-96-17[3]	179.51	46.00	133.51	0.20 U	0.20 U	48.99	130.52	0.20 U	0.20 U
MW-100	177.70	14.52	163.18	0.20 U	0.20 U	18.32	159.38	0.20 U	0.20 U
MW-101A	176.47	17.35	159.12	0.20 U	0.20 U	21.12	155.35	0.20 U	0.20 U
MW-101B	176.41	17.12	159.29	0.20 U	**2.8**	20.93	155.48	0.20 U	**3.2**
MW-102	166.96	8.23	158.73	0.20 U	0.20 U	11.85	155.11	0.20 U	0.20 U
MW-103	163.40	5.32	158.08	0.20 U	0.20 U	8.49	154.91	0.20 U	0.20 U
MW-104A	170.63	50.65	119.98	0.20 U	**3.9**	52.94	117.69	0.20 U	**4.2**
MW-104B	170.52	47.63	122.89	**0.82**	0.20 U	50.36	120.16	**0.74**	0.20 U
MW-107	114.66	7.02	107.64	0.20 U	0.20 U	8.76	105.90	0.20 U	0.20 U
MW-109	168.89	16.89	152.00	0.20 U	**14**	20.88	148.01	0.20 U	**14**
MW-110	101.93	2.24	99.69	0.20 U	0.20 U	3.47	98.46	0.20 U	0.20 U
MW-111	165.41	22.78	142.63	0.20 U	**8.3**	27.05	138.36	0.20 U	**7.1**
MW-ES-02	174.65	51.31	123.34	0.20 U	**36**	53.45	121.20	0.20 U	**34**
MW-ES-03	175.07	45.62	129.45	0.20 U	**15**	–	–	–	–
MW-ES-04	175.11	46.11	129.00	**27**	**0.22**	–	–	–	–
MW-ES-05	175.05	40.43	134.62	0.20 U	**25**	44.06	130.99	0.20 U	**26**
MW-ES-06	173.30	40.78	132.52	**29**	0.20 U	44.48	128.82	**21**	**0.46**
MW-ES-07	177.89	17.85	160.04	0.20 U	**4.6**	21.64	156.25	0.20 U	**4.8**
MW-ES-08	177.17	–	–	–	–	18.17	159.00	–	–
MW-ES-09	108.29	-0.58	108.87	0.40 U	**86**	0.29	108.00	0.40 U	**97**
MW-ES-10	108.21	-2.25	110.46	0.20 U	**29**	-1.14	109.35	0.20 U	**31**
MW-ES-11	166.25	13.01	153.24	0.20 U	**0.31**	16.98	149.27	0.20 U	**0.30**
MW-UI	178.82	17.00	161.82	0.20 U	**10**	20.88	157.94	0.20 U	**7.5**
WDOT-MW-1	166.94	16.69	150.25	0.20 U	0.20 U	21.18	145.76	0.20 U	0.20 U
WDOT-MW-2	165.45	15.05	150.40	0.20 U	0.20 U	17.37	148.08	0.20 U	0.20 U
Piezometers									
PZ-704	110.64	4.18	106.46	–	–	5.83	104.81	–	–
PZ-709	114.67	2.27	112.40	–	–	2.72	111.95	–	–
PZ-715	117.82	3.18	114.64	–	–	4.29	113.53	–	–
PZ-719	106.95	1.83	105.12	0.20 U	**2.2**	2.65	104.30	0.20 U	**2.5**
PZ-720	107.55	3.22	104.33	**0.49**	**9.9**	3.74	103.81	**0.78**	**16**
PZ-721	108.15	2.40	105.75	0.20 U	**34**	3.00	105.15	**0.21**	**37**
PZ-722	108.74	-1.39	110.13	–	–	–	–	–	–
PZ-723	106.22	2.13	104.09	0.20 U	0.20 U	2.76	103.46	0.20 U	0.20 U
PZ-724	106.28	0.74	105.54	0.20 U	**23**	1.78	104.50	0.20 U	**49**
PZ-725	107.88	1.93	105.95	0.20 U	0.20 U	3.21	104.67	0.20 U	**0.23**
PZ-726	105.23	2.66	102.57	0.20 U	**3.4**	3.29	101.94	0.20 U	**3.9**
PZ-728	105.11	1.95	103.16	0.20 U	**3.8**	2.77	102.34	0.20 U	**4.0**
RPZ-730	103.85	2.25	101.60	0.20 U	0.20 U	3.81	100.04	0.20 U	0.20 U
RPZ-731	105.18	3.72	101.46	0.20 U	**0.95**	4.82	100.36	0.20 U	**2.8**
RPZ-732	105.67	4.34	101.33	**0.50**	0.20 U	5.42	100.25	**0.45**	0.20 U
Production Wells/Stripper Towers									
TW-4	108.95	6.20	102.75	–	–	9.50	99.45	0.20 U	**0.60**
TW-8	109.93	4.40	105.53	–	–	31.50	78.43	0.20 U	0.20 U
TW-16	109.43	8.15	101.28	–	–	–	–	–	–
ST-2	–	–	–	–	–	–	–	0.20 U	0.20 U
Barnes Lake (Surface Water)[4]	157.402	-3.44	160.842	–	–	-1.1	158.502	–	–

Notes:

[1] Depth-to-water was measured in monitoring wells, piezometers, production wells, and Barnes Lake on April 18, 2016 (Spring) and August 29, 2016 (Fall).

[2] NAVD 88 = North American Vertical Datum of 1988.

[3] Water level measured through top of hand pump during Spring and Fall 2016.

[4] Measuring point elevation is 0.00 feet on the Barnes Lake staff gauge.

– = Not applicable

BTOC = below top of casing

Groundwater samples for chemical analysis were collected from April 19 to 28 (Spring) and August 30 to September 8 (Fall), 2016.

µg/L = microgram per liter

U = not detected at or above the reporting limit

Bold font type indicates the analyte was detected above the reporting limit.

Gray shading indicates the analyte was detected above the ROD Remediation Goal.

Samples were also analyzed for 1,1-DCE, trans-1,2-DCE, cis-1,2-DCE and vinyl chloride.

Table 3

Mann-Kendall Statistical Trends
2016 Annual Groundwater Monitoring Report
Palermo Wellfield Superfund Site
Tumwater, Washington

Location ID	Total Number of VOC Samples Collected*	PCE Maximum Concentration Detected* (µg/L)/Date	General Long Term PCE Concentration Statistical Trend (95 Percent Confidence Limit)	TCE Maximum Concentration Detected* (µg/L)/ Date	General Long Term TCE Concentration Statistical Trend (95 Percent Confidence Limit)
MW-101B	21	0.1 / Mar 2006	Decreasing	17 / Apr 2009	Decreasing
MW-104A	11	ND	Decreasing	11 / Oct 2006	Decreasing
MW-104B	25	2.4 / Nov 2007	Decreasing	0.26 / May 2004	Decreasing
MW-109	25	ND	Not Detected	32 / Sep 2004	Decreasing
MW-110	25	ND	Not Detected	ND	Not Detected
MW-111	25	ND	Not Detected	22 / May 2004	Decreasing
MW-UI	25	ND	Not Detected	28 / Nov 2007	Decreasing
MW-ES-02	21	ND	Not Detected	68 / Nov 2006	Decreasing
MW-ES-03	24	0.13 / Oct 2005	Decreasing	42 / Sep 2004	Decreasing
MW-ES-04	24	58 / May 2004	Decreasing	1.8 / May 2008	Decreasing
MW-ES-05	25	0.21 / May 2008	Decreasing	58 / May 2008	Decreasing
MW-ES-06	25	49 / Jun 2007	No Statistically Significant Trend	16 / Mar 2006	Decreasing
MW-ES-07	21	0.1 / Mar 2006	Decreasing	11 / Nov 2007	Decreasing
MW-ES-09	25	ND	Not Detected	300 / Apr 2005	Decreasing
MW-ES-10	25	ND	Not Detected	83 / Sep 2004	Decreasing
PZ-719	10	ND	Not Detected	2.5 / Sep 2016	Increasing
PZ-720	11	1.1 / Dec 2004	No Statistically Significant Trend	18 / Aug 2015	No Statistically Significant Trend
PZ-721	23	0.79 / Dec 2004	Decreasing	98 / Dec 2004	No Statistically Significant Trend
PZ-724	23	0.45 / Dec 2004	Decreasing	87 / May 2008	No Statistically Significant Trend
PZ-725	11	ND	Not Detected	0.35 / Dec 2004	No Statistically Significant Trend
PZ-726	11	ND	Not Detected	3.9 / Sep 2016	Increasing
PZ-728	23	ND	Not Detected	51 / Oct 2008	Decreasing
RPZ-731	10	ND	Not Detected	2.8 / Sep 2016	Increasing
TW-4	20	ND	Not Detected	3.4 / Mar 2006	Decreasing

Notes:

*Since long term monitoring began in 2004.

ND = Compound not detected.

Table 4

Neighborhood Piezometer Elevations

2016 Annual Groundwater Monitoring Report
Palermo Wellfield Superfund Site
Tumwater, Washington

Location	Top-of-Casing Elevation (feet NAVD 88) [1,2]	Ground Surface Elevation (feet NAVD 88) [1,2]	Spring 2016		Fall 2016	
			Depth to Water April 18, 2016 (feet BTOC)	Groundwater Elevation (feet NAVD 88) [2]	Depth to Water August 29, 2016 (feet BTOC)	Groundwater Elevation (feet NAVD 88) [2]
Bluff and Rainier Avenue Piezometers						
PZ-704	110.64	108.52	4.18	106.46	5.83	104.81
PZ-709	114.67	111.99	2.27	112.40	2.72	111.95
PZ-715	117.82	115.56	3.18	114.64	4.29	113.53
PZ-720	107.55	108.08	3.22	104.33	3.74	103.81
PZ-721	108.15	108.35	2.40	105.75	3.00	105.15
PZ-722	108.74	109.02	-1.39	110.13	–	–
Other Neighborhood Piezometers						
PZ-719	106.95	107.36	1.83	105.12	2.65	104.30
PZ-723	106.22	106.72	2.13	104.09	2.76	103.46
PZ-724	106.28	106.77	0.74	105.54	1.78	104.50
PZ-725	107.88	108.39	1.93	105.95	3.21	104.67
PZ-726	105.23	105.63	2.66	102.57	3.29	101.94
PZ-728	105.11	105.69	1.95	103.16	2.77	102.34
RPZ-730	103.85	104.36	2.25	101.60	3.81	100.04
RPZ-731	105.18	105.41	3.72	101.46	4.82	100.36
RPZ-732	105.67	105.93	4.34	101.33	5.42	100.25

Notes:

[1] Elevations surveyed by Skillings Connolly, October 2014.

[2] NAVD 88 = North American Vertical Datum of 1988/2011.

BTOC = below top of casing

– = Not applicable

Table 5

Discharge Volume and Analytical Results - Subdrain and Lagoon

2016 Annual Groundwater Monitoring Report

Palermo Wellfield Superfund Site

Tumwater, Washington

Location	Station Description	Spring 2016 Volume (gpm)	Spring 2016 Tetrachloroethene (µg/L)	Spring 2016 Trichloroethene (µg/L)	Fall 2016 Volume (gpm)	Fall 2016 Tetrachloroethene (µg/L)	Fall 2016 Trichloroethene (µg/L)
Flow in Sub-Drain System							
357	Cleanout CO-6	63	**10**	**7.9**	16	**11**	**6.0**
358	Cleanout CO-4	142	**7.0**	**14**	104	**7.3**	**14**
359	Cleanout CO-1	158	**4.4**	**10**	158	**4.0**	**11**
360	Tightline Pipe Outfall	190	**4.1**	**9.6**	98	**3.3**	**9.6**
Treatment Lagoon Inflows (Non-Sub-Drain)							
350	M Street Storm Drain Outfall	111	0.20 U	**1.3**	78	0.20 U	**1.5**
356	Watercourse Upstream of Lagoon	NC	0.20 U	0.20 U	NC	0.20 U	0.20 U
362	M Street Terminus Catch Basin Outfall (rarely flows)	NF	NS	NS	NF	NS	NS
Treatment Lagoon Effluent							
361	Lagoon Effluent	1,667	**0.26**	**0.73**	4,450	**0.20**	**0.66**
Deschutes River Point of Compliance							
364	Deschutes River Outfall	1,906	0.20 U	**0.41**	1,555	0.20 U	**0.42**
Deschutes River Discharge Remediation Goal		–	0.8	2.7	–	0.8	2.7

Notes:

Spring samples were collected on April 26, 2016 and Fall samples were collected on September 8, 2016.
GPM = gallons per minute
µg/L = microgram per liter
NG = no remediation goal
NS = not sampled
NF = no flow; not calculated
NC = not calculated because flow was too slow to measure
U = not detected at or above the reporting limit
Bold font type indicates analyte was detected
Bold font type and gray shading indicates the result exceeds remediation goal
Samples were also analyzed for 1,1-DCE, trans-1,2-DCE, cis-1,2-DCE and vinyl chloride.

Table 6

Sediment Accumulation in Catch Basins and Cleanouts in Subdrain System

2016 Annual Groundwater Monitoring Report
Palermo Wellfield Superfund Site
Tumwater, Washington

Location	Depth to Water (feet)	Water Elevation (feet)[1]	Original Total Depth (Feb. 2001) (feet)	Measured Total Depth (feet)	Net Change[2] (feet)	Catch Basin and Subdrain Cleanout Observations
Spring 2016 (April 26, 2016)						
CB-1	5.18	100.09	7.78	7.90	-0.12	free of debris, fast flow, gravel in sump bottom, growth in outlet.
CB-2	6.57	101.35	8.78	8.75	0.03	Free of debris, fast flow, hard sump bottom.
CB-3	6.24	101.59	8.81	8.86	-0.05	Free of debris, fast flow, soft sump bottom.
CO-1 (359)	6.15	102.13	7.82	7.73	0.09	Free of debris, moderate flow, soft sump bottom, turbulent.
CO-2	5.66	102.29	7.10	7.16	-0.06	Free of debris, moderate flow, soft sump bottom.
CO-3	5.47	102.41	6.84	6.73	0.11	Free of debris, moderate flow, hard sump bottom.
CO-4 (358)	6.15	102.47	7.84	7.06	0.78	Numerous roots in pipe, moderate flow, hard sump bottom.
CO-5	6.58	102.62	7.84	7.46	0.38	Free of debris, moderate flow, soft sump bottom.
CO-6 (357)	5.32	104.33	7.70	7.38	0.32	Free of debris, slow flow, soft sump bottom, water ponded over cleanout lid.
CO-7	6.21	104.43	7.89	7.12	0.77	Some roots visible in pipe, slow flow, soft sump bottom.
CO-8	6.29	104.45	8.10	7.81	0.29	Free of debris, slow flow, soft sump bottom, strong odor.
Fall 2016 (September 8, 2016)						
CB-1	5.16	100.11	7.78	7.93	-0.15	Gravel debris, moderate flow, hard to soft sump bottom, growth in outlet.
CB-2	6.63	101.29	8.78	8.79	-0.01	Free of debris, moderate flow, hard sump bottom.
CB-3	6.21	101.62	8.81	8.99	-0.18	Free of debris, moderate flow, soft sump bottom.
CO-1 (359)	6.18	102.10	7.82	7.82	0.00	Free of debris, moderate flow, turbulent, soft sump bottom.
CO-2	5.74	102.21	7.10	7.25	-0.15	Free of debris, moderate flow, soft sump bottom.
CO-3	5.58	102.30	6.84	6.84	0.00	Free of debris, moderate flow, hard sump bottom.
CO-4 (358)	6.20	102.42	7.84	7.25	0.59	Roots present in sump, moderate flow, hard sump bottom.
CO-5	6.63	102.57	7.84	7.88	-0.04	Free of debris, moderate flow, soft sump bottom.
CO-6 (357)	3.65	106.00	7.70	7.45	0.25	Free of debris, slow flow, soft sump bottom, ponded water over cleanout lid.
CO-7	4.52	106.12	7.89	7.28	0.61	Roots present in sump, slow flow, soft sump bottom.
CO-8	4.55	106.19	8.10	7.35	0.75	Free of debris, slow flow, soft sump bottom, strong odor, water level higher than usual.

Notes:

Exceeds 0.5 foot accumulated sediment (Section 4.2.1 Trunk Drain, O&M Manual, URS, 2002)

[1] NAVD 88 = North American Vertical Datum of 1988/2011.

[2] Net change = original total depth from February 2001 minus the measured total depth.

Table 7

Subdrain Performance

2016 Annual Groundwater Monitoring Report
Palermo Wellfield Superfund Site
Tumwater, Washington

Compliance Station	Ground Surface Elevation [1] (feet)	Measuring Point Top of Casing Elevation [1] (feet)	Difference in Elevation [2] (feet)	Measured Depth to Water [3] (feet BTOC)	Calculated Depth to Water [4] (feet bgs)	Calculated Groundwater Elevation [5] (feet bgs)	3 Foot Elevation Reduction Met [6]
Spring 2016							
PZ-720	108.08	107.55	0.53	3.22	3.75	104.33	Yes
PZ-721	108.35	108.15	0.20	2.40	2.60	105.75	No
PZ-722	109.02	108.74	0.28	-1.39	-1.11	110.13	No
Fall 2016							
PZ-720	108.08	107.55	0.53	3.74	4.27	103.81	Yes
PZ-721	108.35	108.15	0.20	3.00	3.20	105.15	Yes
PZ-722	109.02	108.74	0.28	–	–	–	–

Notes:

[1] Elevations relative to NAVD 88. Surveyed by Skillings Connolly, October 2014.

[2] Ground surface elevation minus measuring point top of casing elevation.

[3] Depth to water measured relative to top of casing.

[4] Depth to water calculated relative to ground surface (depth to water measurement plus difference in elevation between ground surface elevation and measuring point top of casing elevation).

[5] Ground surface elevation minus calculated depth to water relative to ground surface.

[6] Performance is evaluated based on achieving a 3 foot water level reduction at piezometers PZ-720, PZ-721, and PZ-722 relative to ground surface elevation (also equivalent to 18 inches below crawlspace floors).

BTOC = below top of casing

bgs = below ground surface

– = Not applicable because PZ-722 was damaged.

FIGURES

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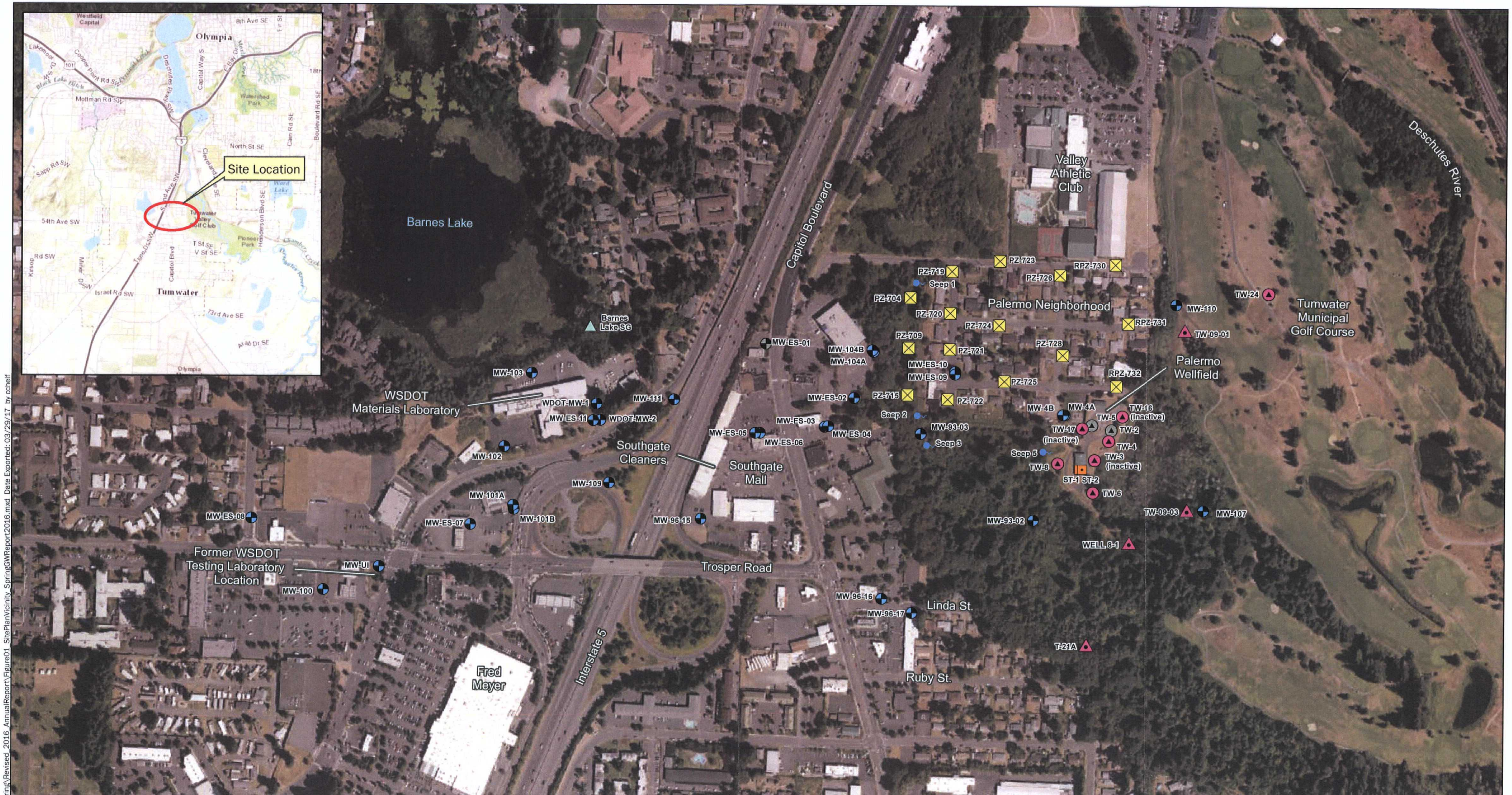

Notes:

1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.
3. TW-3, TW-16 and TW-17 are installed but not operating.

Data Source: Long-term monitoring locations provided by Parametrix 2012 and modified using surveyed well and piezometer locations by Skillings Connolly, Inc, Oct. 2014.
Imagery from Thurston County GIS 2015.
Projection: NAD 1983 StatePlane Washington South FIPS 4602 Feet

Monitoring well and identifier
Piezometer and identifier
Groundwater seep and identifier
City production well and identifier
City test well and identifier
Stripper tower and identifier
Barnes Lake staff gauge
Former city production well and identifier
Former monitoring well and identifier

N W E S

400 0 400
Feet

Site Plan

Palermo Wellfield Superfund Site

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Figure 1

P:\0\0180121\GIS\MXDs\GroundWater_Monitoring\Revised_2016_AnnualReport\Figure01_SitePlanVicinity_SpringGWReport2016.mxd Date Exported: 03/29/17 by cchelf

Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.
3. TW-3, TW-16, and TW-17 are installed but not operating.

Data Source: Long-term monitoring locations from Parametrix 2012. Subdrain layout provided by URS 2000 and modified using surveyed cleanout and catch basin point locations by Skillings Connolly, Inc. Oct 2014, Imagery from Thurston County GIS 2015.
Projection: NAD 1983 StatePlane Washington South FIPS 4602 Feet

Monitoring well and identifier
Piezometer and identifier
Groundwater seep and identifier
City production well and identifier
City test well and identifier
Stripper tower and identifier
Former city production well and identifier
Catch basin and identifier
Subdrain cleanout sampling station and identifier
Treatment lagoon sampling station and identifier
Cleanout location and identifier
Subdrain tightline pipe
Subdrain perforated pipe

N E S W

120 0 120
Feet

Palermo Neighborhood and Subdrain

Palermo Wellfield Superfund Site

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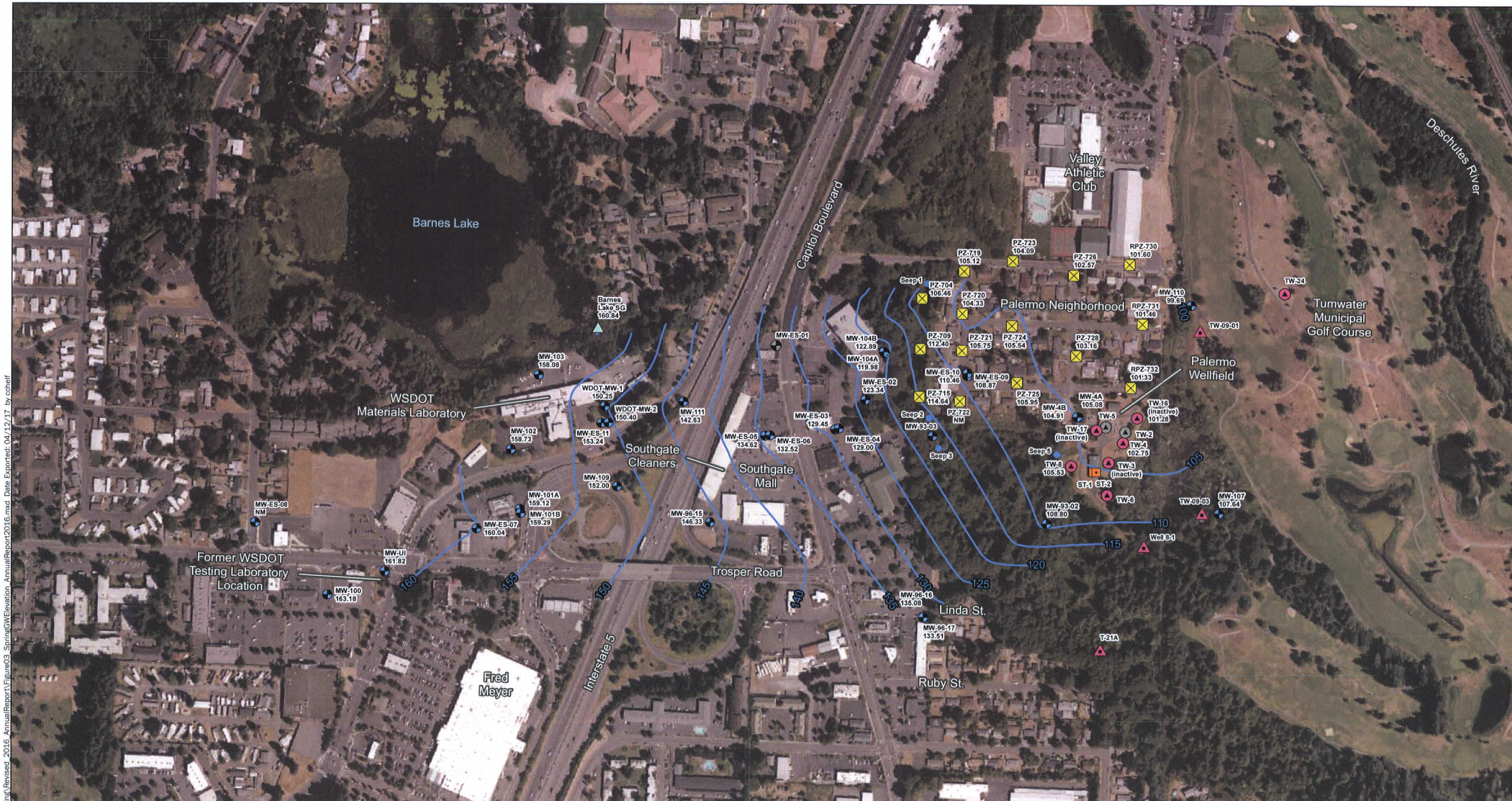
Figure 2

P:\0\0180121\GIS\MXDs\GroundWater_Monitoring\Revised_2016_AnnualReport\Figure02_NeighborhoodPlan_SpringGWReport2016.mxd Date Exported: 04/06/17 by cchelf



Notes:
1. TW-3, TW-16 and TW-17 are installed but not operating.
2. Groundwater levels measured April 18, 2016.
3. Groundwater elevation contours estimated using Surfer (Golden Software) 8.0 contouring software using the Natural Neighbor gridding method.
4. Groundwater elevations are relative to NAVD 88.
5. The locations of all features shown are approximate.
6. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc.and will serve as the official record of this communication.

Data Source: Long-term monitoring locations provided by Parametrix 2012 and modified using surveyed well and piezometer locations by Skillings Connolly, Inc, Oct. 2014. Imagery from Thurston County 2015.

Projection: NAD 1983 StatePlane Washington South FIPS 4602 Feet

Monitoring well and identifier
Piezometer and identifier
Groundwater seep and identifier
City production well and identifier
City test well and identifier
Stripper tower and identifier
Barnes Lake staff gauge
Former city production well and identifier
Former monitoring well and identifier
100 Estimated groundwater elevation
NM Not Measured

N W E S

400 0 400
Feet

Spring 2016
Generalized Groundwater Elevations

Palermo Wellfield Superfund Site

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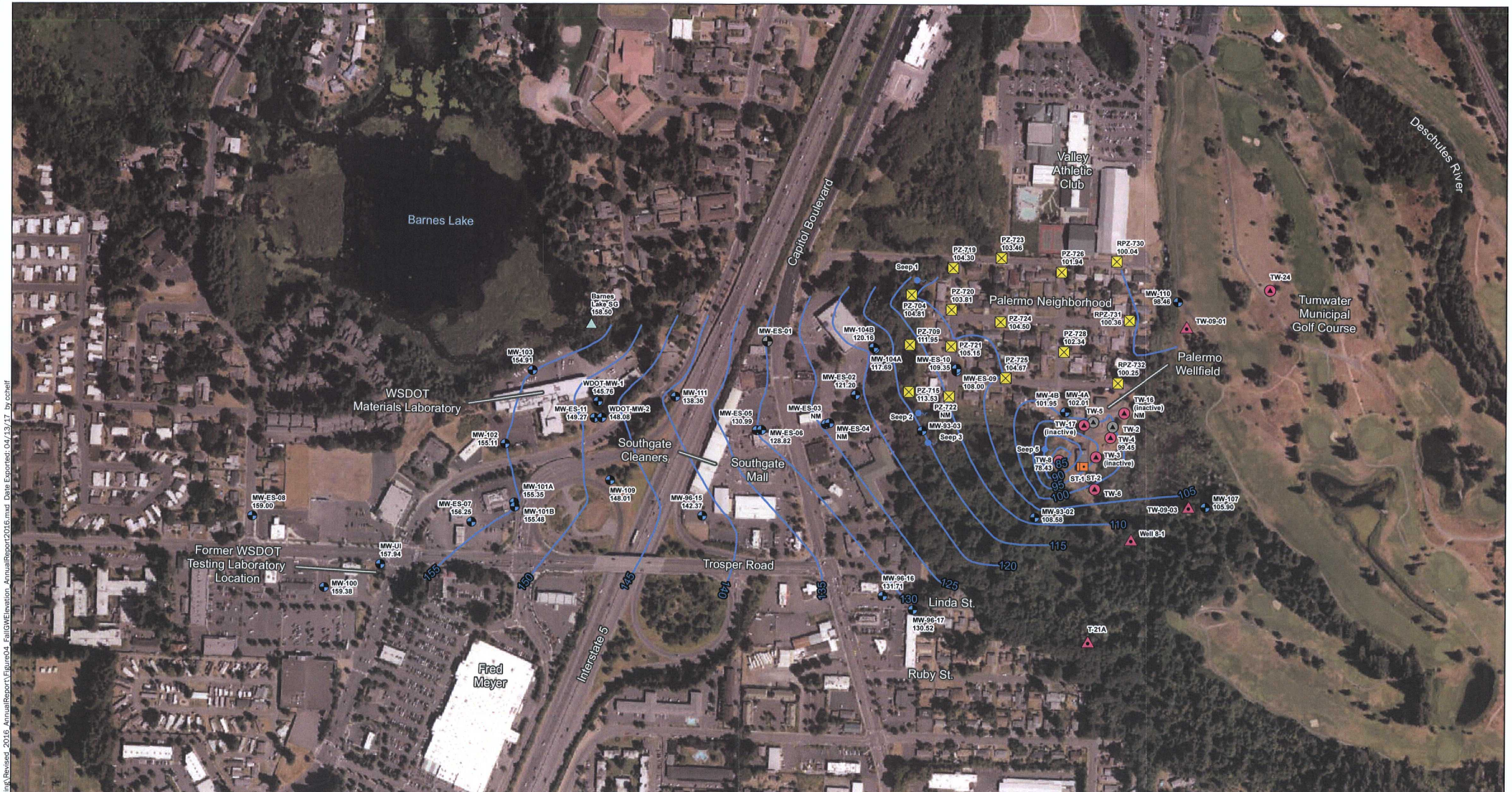
Figure 3

P:\0\0180121\GIS\MXDs\GroundWater_Monitoring\Revised_2016_AnnualReport\Figure03_SpringGWElevation_AnnualReport2016.mxd Date Exported: 04/12/17 by ccheif



Notes:

1. TW-3, TW-16 and TW-17 are installed but not operating.
2. Groundwater levels measured August 29, 2016.
3. Groundwater elevation contours estimated using Surfer (Golden Software) 8.0 contouring software using the Natural Neighbor gridding method.
4. Groundwater elevations are relative to NAVD 88.
5. The locations of all features shown are approximate.
6. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc.and will serve as the official record of this communication.

Data Source: Long-term monitoring locations provided by Parametrix 2012 and modified using surveyed well and piezometer locations by Skillings Connolly, Inc, Oct. 2014. Imagery from Thurston County 2015.

Projection: NAD 1983 StatePlane Washington South FIPS 4602 Feet

- Monitoring well and identifier
- Piezometer and identifier
- Groundwater seep and identifier
- City production well and identifier
- City test well and identifier
- Stripper tower and identifier
- Barnes Lake staff gauge
- Former city production well and identifier
- Former monitoring well and identifier
- 100 Estimated groundwater elevation
- NM Not Measured

N W E S

400 0 400

Feet

Fall 2016
Generalized Groundwater Elevations

Palermo Wellfield Superfund Site

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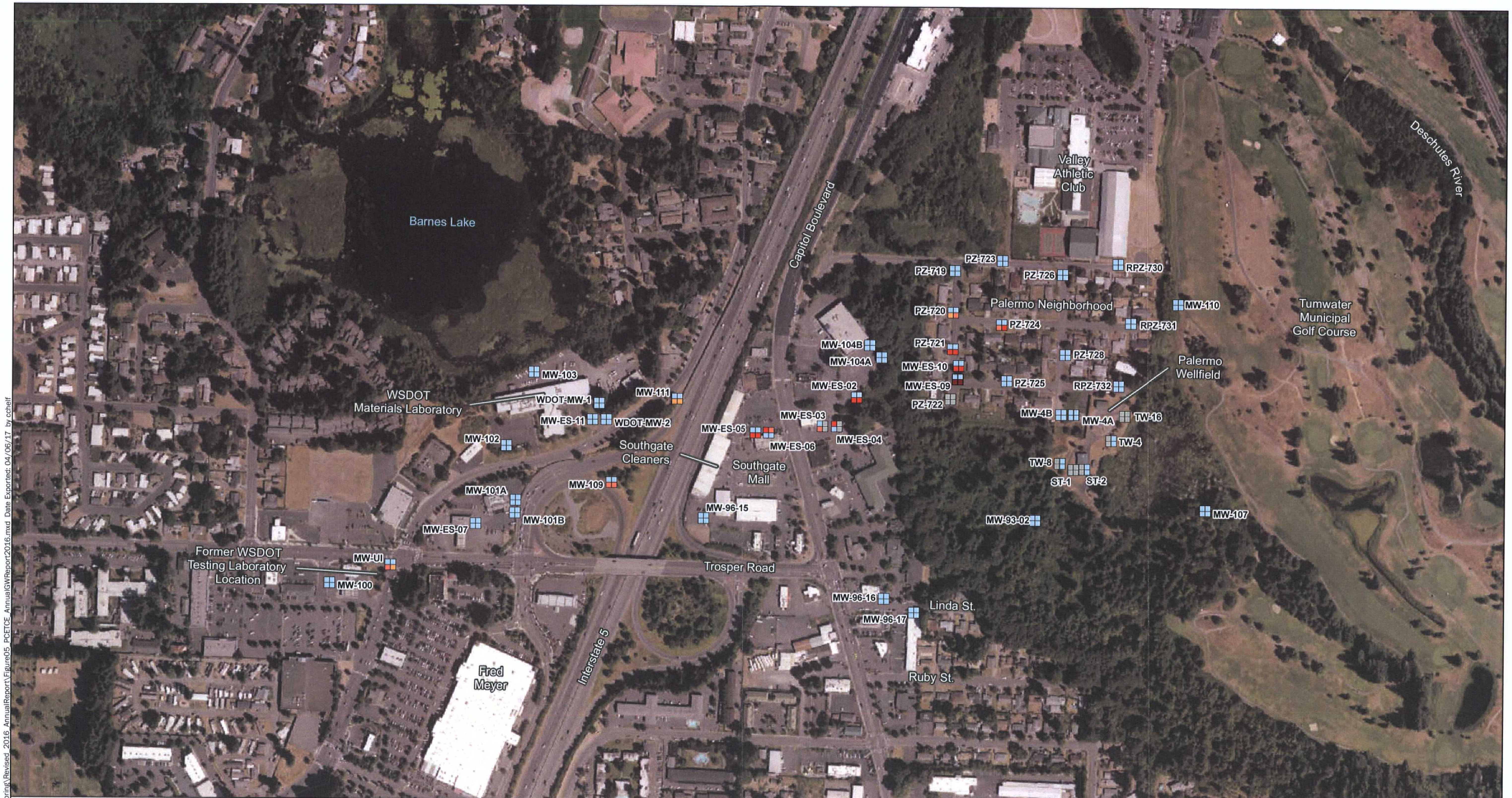
Figure 4

P:\0\0180121\GIS\MXDs\GroundWater_Monitoring\Revised_2016_AnnualReport\Figure04_FallGWElevation_AnnualReport2016.mxd Date Exported: 04/13/17 by cchelf



Notes:
1. Concentrations presented in µg/L.
2. The Record of Decision (ROD) Remediation Goal (RG) was established at 5 ug/L for PCE and TCE (EPA, 1999).
3. TW-3, TW-16 and TW-17 are installed but not operating.
4. Groundwater samples collected from April 19 to 28 (Spring) and August 30 to September 8 (Fall), 2016.
5. The locations of all features shown are approximate.
6. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Data Source: Long-term monitoring locations provided by Parametrix 2012 and modified using surveyed well and piezometer locations by Skillings Connolly, Inc, Oct. 2014. Imagery from Thurston County 2015.

Projection: NAD 1983 StatePlane Washington South FIPS 4602 Feet

Spring 2016 PCE | Fall 2016 PCE

Spring 2016 TCE | Fall 2016 TCE

- Greater than or equal to 50 µg/L (10 times ROD RG)
- Greater than or equal to 25 µg/L (5 times ROD RG)
- Greater than or equal to 10 µg/L (2 times ROD RG)
- Greater than or equal to 5 µg/L (ROD RG)
- Not detected or detected at less than ROD RG
- Sample not collected

N W E S

400 0 400

Feet

PCE and TCE Concentrations in Groundwater (µg/L) Spring and Fall 2016

Palermo Wellfield Superfund Site

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Figure 5

P:\0\0180121\GIS\MXDs\GroundWater_Monitoring\Revised_2016_AnnualReport\Figure05_PCETCE_AnnualGWReport2016.mxd Date Exported: 04/06/17 by cchelf

Notes:

1. Contours were generated using Surfer 8.0 (Golden Software) contouring software using the natural neighbor gridding method from water levels measured on April 18th and 26th, 2016.
2. Groundwater elevations are relative to NAVD 88.
3. The locations of all features shown are approximate.
4. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Data Source: Long-term monitoring locations from Parametrix 2012. Subdrain layout provided by URS 2000 and modified using surveyed cleanout and catch basin point locations by Skillings Connolly, Inc. Oct 2014, Imagery from Thurston County 2012.
Projection: NAD 1983 StatePlane Washington South FIPS 4602 Feet

Monitoring well and identifier
Piezometer and identifier
Groundwater seep and identifier
City production well and identifier
City test well and identifier
Stripper tower and identifier
Former city production well and identifier
Catch basin and identifier
Subdrain cleanout sampling station and identifier
Treatment lagoon sampling station and identifier
Cleanout location and identifier
Subdrain tightline pipe
Subdrain perforated pipe
Estimated or inferred groundwater elevation contours

N
W E
S

120 0 120
Feet

Spring 2016 - Palermo Neighborhood Shallow Groundwater Elevations

Palermo Wellfield Superfund Site

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Figure 6

P:\0\0180121\GIS\MXDs\GroundWater_Monitoring\Revised_2016_AnnualReport\Figure06_SpringSubdrainGWElevations_AnnualReport2016.mxd Date Exported: 04/07/17 by cchelf

Notes:

1. Contours were generated using Surfer 8.0 (Golden Software) contouring software using the natural neighbor gridding method from water levels measured on August 29 and September 8, 2016.
2. Groundwater elevations are relative to NAVD 88.
3. The locations of all features shown are approximate.
4. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Data Source: Long-term monitoring locations from Parametrix 2012. Subdrain layout provided by URS 2000 and modified using surveyed cleanout and catch basin point locations by Skillings Connolly, Inc. Oct 2014, Imagery from Thurston County GIS 2012.
Projection: NAD 1983 StatePlane Washington South FIPS 4602 Feet

- Monitoring well and identifier
- Piezometer and identifier
- Groundwater seep and identifier
- City production well and identifier
- City test well and identifier
- Stripper tower and identifier
- Former city production well and identifier
- Catch basin and identifier
- Subdrain cleanout sampling station and identifier
- Treatment lagoon sampling station and identifier
- Cleanout location and identifier
- Subdrain tightline pipe
- Subdrain perforated pipe
- Estimated or inferred groundwater elevation contours

N E S W

120 0 120

Feet

Fall 2016 - Palermo Neighborhood Shallow Groundwater Elevations

Palermo Wellfield Superfund Site

GEOENGINEERS

Figure 7

P:\0\0180121\GIS\MXDs\GroundWater_Monitoring\Revised_2016_AnnualReport\Figure07_FallSubdrainGWElevations_AnnualReport2016.mxd Date Exported: 03/29/17 by ccheif

359 (CO1)		Spring	Fall
	PCE (µg/L)	4.4	4.0
	TCE (µg/L)	10	11
	Flow (gpm)	158	158

358 (CO4)		Spring	Fall
	PCE (µg/L)	7.0	7.3
	TCE (µg/L)	14	14
	Flow (gpm)	142	104

357 (CO6)		Spring	Fall
	PCE (µg/L)	10	11
	TCE (µg/L)	7.9	6.0
	Flow (gpm)	63	16

364 Deschutes River POC		Spring	Fall
	PCE (µg/L)	0.20 U	0.20 U
	TCE (µg/L)	0.41	0.42
	Flow (gpm)	1906	1,555

361 (Lagoon effluent)		Spring	Fall
	PCE (µg/L)	0.26	0.20 U
	TCE (µg/L)	0.73	0.66
	Flow (gpm)	1,667	4,450

350 (M St storm drain)		Spring	Fall
	PCE (µg/L)	0.20 U	0.20 U
	TCE (µg/L)	1.3	1.5
	Flow (gpm)	111	78

360 (tight line outfall)		Spring	Fall
	PCE (µg/L)	4.1	3.3
	TCE (µg/L)	9.6	9.6
	Flow (gpm)	190	98

356 (Upstream)		Spring	Fall
	PCE (µg/L)	0.20 U	0.20 U
	TCE (µg/L)	0.20 U	0.20 U
	Flow (gpm)	NC	NC

Notes:
1. TW-3, TW-16 and TW-17 are installed but not operating.
2. Subdrain and lagoon samples were collected on April 26 and September 8, 2016.
3. The locations of all features shown are approximate.
4. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.
5. Discharge for Station 361 is measured at an outfall approximately 800 feet downstream at a pond located north of the Tumwater Athletic Club.
6. Station 364, the Deschutes River Point of Compliance (POC) point, is located at the Deschutes River Outfall located approximately 2,000 feet downstream from the treatment lagoon.
7. No flow or samples were collected at Station 362 because water was not present.
Data Source: Long term monitoring locations provided by Parametrix 2012 and Skillngs Connolly, Inc. 2014. Imagery from Thurston County GIS 2015.
Projection: NAD 1983 StatePlane Washington South FIPS 4602 Feet

Monitoring well and identifier
Piezometer and identifier
Groundwater seep and identifier
City production well and identifier
City test well and identifier
Stripper tower and identifier
Former city production well and identifier
Catch basin and identifier
Subdrain cleanout sampling station and identifier
Treatment lagoon sampling station and identifier
Cleanout location and identifier
U Compound not detected at the reporting limit
Subdrain tightline pipe
Subdrain perforated pipe
NC Not calculated

N W E S

120 0 120
Feet

Subdrain and Treatment Lagoon Monitoring Results Palermo Neighborhood

Palermo Wellfield Superfund Site

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Figure 8

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APPENDICES

GeoEngineers

APPENDIX A
Field Forms
(Included on CD)

APPENDIX B
Analytical Data Summary Tables

Table B-1

Groundwater Results

Spring 2016 Semiannual Groundwater Monitoring Report
Palermo Wellfield Superfund Site
Tumwater, Washington

				1,1-Dichloroethene	cis-1,2-Dichloroethene	Tetrachloroethene	Trans-1,2-Dichloroethene	Trichloroethene	Vinyl Chloride
Location	Sample ID	Date	Type	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)
MW-100	MW-100-160419	4/19/2016	Primary	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U
MW-101A	MW-101A-160419	4/19/2016	Primary	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U
MW-101A	DUP-1-160419	4/19/2016	Duplicate	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U
MW-101B	MW-101B-160419	4/19/2016	Primary	0.20 U	0.20 U	0.20 U	0.20 U	**2.8**	0.20 U
MW-102	MW-102-160420	4/20/2016	Primary	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U
MW-103	MW-103-160420	4/20/2016	Primary	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U
MW-104A	MW-104A-160422	4/22/2016	Primary	0.20 U	0.20 U	0.20 U	0.20 U	**3.9**	0.20 U
MW-104B	MW-104B-160422	4/22/2016	Primary	0.20 U	0.20 U	**0.82**	0.20 U	0.20 U	0.20 U
MW-104B	DUP-2-160422	4/22/2016	Duplicate	0.20 U	0.20 U	**0.80**	0.20 U	0.20 U	0.20 U
MW-107	MW-107-160421	4/21/2016	Primary	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U
MW-109	MW-109-160419	4/19/2016	Primary	0.20 U	0.20 U	0.20 U	0.20 U	**14**	0.20 U
MW-110	MW-110-160421	4/21/2016	Primary	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U
MW-111	MW-111-160421	4/21/2016	Primary	0.20 U	0.20 U	0.20 U	0.20 U	**8.3**	0.20 U
MW-4A	MW-4A-160420	4/20/2016	Primary	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U
MW-4B	MW-4B-160420	4/20/2016	Primary	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U
MW-93-02	MW-93-02-160421	4/21/2016	Primary	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U
MW-96-15	MW-96-15-160420	4/20/2016	Primary	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U
MW-96-16	MW-96-16-160421	4/21/2016	Primary	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U
MW-96-17	MW-96-17-160421	4/21/2016	Primary	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U
MW-ES-02	MW-ES-02-160422	4/22/2016	Primary	0.20 U	0.20 U	0.20 U	0.20 U	**36**	0.20 U
MW-ES-03	MW-ES-03-160421	4/21/2016	Primary	0.20 U	0.20 U	0.20 U	0.20 U	**15**	0.20 U
MW-ES-04	MW-ES-04-160421	4/21/2016	Primary	0.20 U	0.20 U	**27**	0.20 U	**0.22**	0.20 U
MW-ES-05	MW-ES-05-160422	4/22/2016	Primary	0.20 U	0.20 U	0.20 U	0.20 U	**25**	0.20 U
MW-ES-06	MW-ES-06-160422	4/22/2016	Primary	0.20 U	0.20 U	**29**	0.20 U	0.20 U	0.20 U
MW-ES-07	MW-ES-07-160419	4/19/2016	Primary	0.20 U	0.20 U	0.20 U	0.20 U	**4.6**	0.20 U
MW-ES-07	DUP-2-160419	4/19/2016	Duplicate	0.20 U	0.20 U	0.20 U	0.20 U	**4.7**	0.20 U
MW-ES-09	MW-ES-09-160422	4/22/2016	Primary	0.40 U	0.40 U	0.40 U	0.40 U	**86**	0.40 U
MW-ES-10	MW-ES-10-160422	4/22/2016	Primary	0.20 U	0.20 U	0.20 U	0.20 U	**29**	0.20 U
MW-ES-11	MW-ES-11-160420	4/20/2016	Primary	0.20 U	0.20 U	0.20 U	0.20 U	**0.31**	0.20 U
MW-UI	MW-UI-160419	4/19/2016	Primary	0.20 U	**0.24**	0.20 U	0.20 U	**10**	0.20 U
PZ-719	PZ-719-160428	4/28/2016	Primary	0.20 U	0.20 U	0.20 U	0.20 U	**2.2**	0.20 U
PZ-720	PZ-720-160428	4/28/2016	Primary	0.20 U	0.20 U	**0.49**	0.20 U	**9.9**	0.20 U
PZ-721	PZ-721-160428	4/28/2016	Primary	0.20 U	**0.26**	0.20 U	0.20 U	**34**	0.20 U
PZ-723	PZ-723-160427	4/27/2016	Primary	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U
PZ-724	PZ-724-160428	4/28/2016	Primary	0.20 U	**0.26**	0.20 U	0.20 U	**23**	0.20 U
PZ-725	DUP-2-160428	4/28/2016	Duplicate	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U
PZ-725	PZ-725-160428	4/28/2016	Primary	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U
PZ-726	PZ-726-160427	4/27/2016	Primary	0.20 U	0.20 U	0.20 U	0.20 U	**3.4**	0.20 U
PZ-728	PZ-728-160427	4/27/2016	Primary	0.20 U	**0.22**	0.20 U	0.20 U	**3.8**	0.20 U
RPZ-730	RPZ-730-160427	4/27/2016	Primary	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U
RPZ-731	RPZ-731-160427	4/27/2016	Primary	0.20 U	0.20 U	0.20 U	0.20 U	**0.95**	0.20 U
RPZ-732	RPZ-732-160427	4/27/2016	Primary	0.20 U	0.20 U	**0.50**	0.20 U	0.20 U	0.20 U
WDOT-MW-1	WDOT-MW-1-160420	4/20/2016	Primary	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U
WDOT-MW-2	WDOT-MW-2-160420	4/20/2016	Primary	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U

Notes:

µg/L = micrograms per liter

U = not detected at or above the reporting detection limit

Bold = detected result above the reporting detection limit.

Table B-2

Subdrain Results

Spring 2016 Semiannual Groundwater Monitoring Report
Palermo Wellfield Superfund Site
Tumwater, Washington

Location	Sample ID	Date	Type	1,1-Dichloroethene (µg/L)		cis-1,2-Dichloroethene (µg/L)		Tetrachloroethene (µg/L)		Trans-1,2-Dichloroethene (µg/L)		Trichloroethene (µg/L)		Vinyl Chloride (µg/L)	
Sub-Drain System															
350	350-160426	4/26/2016	Primary	0.20	U	0.20	U	0.20	U	0.20	U	**1.3**		0.20	U
356	356-160426	4/26/2016	Primary	0.20	U	0.20	U	0.20	U	0.20	U	0.20	U	0.20	U
357	357-160426	4/26/2016	Primary	0.20	U	0.20	U	**10**		0.20	U	**7.9**		0.20	U
357	DUP-1-160426	4/26/2016	Duplicate	0.20	U	0.20	U	**10**		0.20	U	**7.8**		0.20	U
358	358-160426	4/26/2016	Primary	0.20	U	0.20	U	**7.0**		0.20	U	**14**		0.20	U
359	359-160426	4/26/2016	Primary	0.20	U	0.20	U	**4.4**		0.20	U	**10**		0.20	U
360	360-160426	4/26/2016	Primary	0.20	U	0.20	U	**4.1**		0.20	U	**9.6**		0.20	U
361	361-160426	4/26/2016	Primary	0.20	U	0.20	U	**0.26**		0.20	U	**0.73**		0.20	U
364	364-160426	4/26/2016	Primary	0.20	U	0.20	U	0.20	U	0.20	U	**0.41**		0.20	U

Notes:

µg/L = micrograms per liter

U = not detected at or above the reporting detection limit

Bold = detected result above the reporting detection limit.

Table B-3

Groundwater Results

Fall 2016 Semiannual Groundwater Monitoring Report
Palermo Wellfield Superfund Site
Tumwater, Washington

Location	Sample ID	Date	Type	1,1-Dichloroethene (µg/L)	cis-1,2-Dichloroethene (µg/L)	Tetrachloroethene (µg/L)	Trans-1,2-Dichloroethene (µg/L)	Trichloroethene (µg/L)	Vinyl Chloride (µg/L)
MW-100	MW-100-160830	8/30/2016	Primary	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U
MW-101A	MW-101A-160830	8/30/2016	Primary	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U
MW-101B	MW-101B-160830	8/30/2016	Primary	0.20 U	0.20 U	0.20 U	0.20 U	**3.2**	0.20 U
MW-102	MW-102-160901	9/1/2016	Primary	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U
MW-103	MW-103-160901	9/1/2016	Primary	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U
MW-104A	MW-104A-160902	9/2/2016	Primary	0.20 U	0.20 U	0.20 U	0.20 U	**4.2**	0.20 U
MW-104B	MW-104B-160902	9/2/2016	Primary	0.20 U	0.20 U	**0.74**	0.20 U	0.20 U	0.20 U
MW-107	MW-107-160901	9/1/2016	Primary	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U
MW-109	MW-109-160830	8/30/2016	Primary	0.20 U	0.20 U	0.20 U	0.20 U	**14**	0.20 U
MW-110	MW-110-160901	9/1/2016	Primary	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U
MW-111	MW-111-160831	8/31/2016	Primary	0.20 U	0.20 U	0.20 U	0.20 U	**7.1**	0.20 U
MW-4A	MW-4A-160831	8/31/2016	Primary	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U
MW-4B	MW-4B-160831	8/31/2016	Primary	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U
MW-93-02	MW-93-02-160901	9/1/2016	Primary	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U
MW-96-15	MW-96-15-160831	8/31/2016	Primary	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U
MW-96-16	MW-96-16-160902	9/2/2016	Primary	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U
MW-96-16	DUP-2-160902	9/2/2016	Duplicate	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U
MW-96-17	MW-96-17-160901	9/1/2016	Primary	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U
MW-ES-02	MW-ES-02-160831	8/31/2016	Primary	0.20 U	0.20 U	0.20 U	0.20 U	**34**	0.20 U
MW-ES-02	DUP-2-160831	8/31/2016	Duplicate	0.20 U	0.20 U	0.20 U	0.20 U	**34**	0.20 U
MW-ES-05	MW-ES-05-160831	8/31/2016	Primary	0.20 U	0.20 U	0.20 U	0.20 U	**26**	0.20 U
MW-ES-06	MW-ES-06-160831	8/31/2016	Primary	0.20 U	0.20 U	**21**	0.20 U	**0.46**	0.20 U
MW-ES-07	MW-ES-07-160830	8/30/2016	Primary	0.20 U	0.20 U	0.20 U	0.20 U	**4.8**	0.20 U
MW-ES-09	MW-ES-09-160906	9/6/2016	Primary	0.40 U	**0.52**	0.40 U	0.40 U	**97**	0.40 U
MW-ES-10	MW-ES-10-160906	9/6/2016	Primary	0.20 U	0.20 U	0.20 U	0.20 U	**31**	0.20 U
MW-ES-11	MW-ES-11-160902	9/2/2016	Primary	0.20 U	0.20 U	0.20 U	0.20 U	**0.30**	0.20 U
MW-UI	MW-UI-160830	8/30/2016	Primary	0.20 U	0.20 U	0.20 U	0.20 U	**7.5**	0.20 U
MW-UI	DUP-2-160830	8/30/2016	Duplicate	0.20 U	0.20 U	0.20 U	0.20 U	**8.0**	0.20 U
PZ-719	PZ-719-160907	9/7/2016	Primary	0.20 U	0.20 U	0.20 U	0.20 U	**2.5**	0.20 U
PZ-720	PZ-720-160907	9/7/2016	Primary	0.20 U	0.20 U	**0.78**	0.20 U	**16**	0.20 U
PZ-721	PZ-721-160907	9/7/2016	Primary	0.20 U	**0.78**	**0.21**	0.20 U	**37**	0.20 U
PZ-723	PZ-723-160906	9/6/2016	Primary	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U
PZ-724	PZ-724-160907	9/7/2016	Primary	0.20 U	**0.66**	0.20 U	0.20 U	**49**	0.20 U
PZ-725	PZ-725-160907	9/7/2016	Primary	0.20 U	0.20 U	0.20 U	0.20 U	**0.23**	0.20 U
PZ-726	PZ-726-160906	9/6/2016	Primary	0.20 U	0.20 U	0.20 U	0.20 U	**3.9**	0.20 U
PZ-726	DUP-2-160906	9/6/2016	Duplicate	0.20 U	0.20 U	0.20 U	0.20 U	**4.0**	0.20 U
PZ-728	PZ-728-160906	9/6/2016	Primary	0.20 U	0.20 U	0.20 U	0.20 U	**4.0**	0.20 U
RPZ-730	RPZ-730-160906	9/6/2016	Primary	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U
RPZ-731	RPZ-731-160906	9/6/2016	Primary	0.20 U	0.20 U	0.20 U	0.20 U	**2.8**	0.20 U
RPZ-732	RPZ-732-160906	9/6/2016	Primary	0.20 U	0.20 U	**0.45**	0.20 U	0.20 U	0.20 U
ST-2	ST-2-160906	9/6/2016	Primary	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U
TW-4	TW-4-160906	9/6/2016	Primary	0.20 U	0.20 U	0.20 U	0.20 U	**0.60**	0.20 U
TW-8	TW-8-160906	9/6/2016	Primary	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U
WDOT-MW-1	WDOT-MW-1-160902	9/2/2016	Primary	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U
WDOT-MW-2	WDOT-MW-2-160902	9/2/2016	Primary	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U

Notes:

µg/L = micrograms per liter

U = not detected at or above the reporting detection limit

Bold = detected result above the reporting detection limit.

Table B-4

Subdrain Results

Fall 2016 Semiannual Groundwater Monitoring Report
Palermo Wellfield Superfund Site
Tumwater, Washington

Location	Sample ID	Date	Type	1,1-Dichloroethene (µg/L)		cis-1,2-Dichloroethene (µg/L)		Tetrachloroethene (µg/L)		Trans-1,2-Dichloroethene (µg/L)		Trichloroethene (µg/L)		Vinyl Chloride (µg/L)	
Sub-Drain System															
350	350-160908	9/8/2016	Primary	0.20	U	0.20	U	0.20	U	0.20	U	**1.5**		0.20	U
356	356-160908	9/8/2016	Primary	0.20	U	0.20	U	0.20	U	0.20	U	0.20	U	0.20	U
357	357-160908	9/8/2016	Primary	0.20	U	0.20	U	**11**		0.20	U	**6.0**		0.20	U
357	DUP-1-160908	9/8/2016	Duplicate	0.20	U	0.20	U	**11**		0.20	U	**5.7**		0.20	U
358	358-160908	9/8/2016	Primary	0.20	U	0.20	U	**7.3**		0.20	U	**14**		0.20	U
359	359-160908	9/8/2016	Primary	0.20	U	0.20	U	**4.0**		0.20	U	**11**		0.20	U
360	360-160908	9/8/2016	Primary	0.20	U	0.20	U	**3.3**		0.20	U	**9.6**		0.20	U
361	361-160908	9/8/2016	Primary	0.20	U	0.20	U	**0.2**		0.20	U	**0.66**		0.20	U
364	364-160908	9/8/2016	Primary	0.20	U	0.20	U	0.20	U	0.20	U	**0.42**		0.20	U

Notes:

µg/L = micrograms per liter

U = not detected at or above the reporting detection limit

Bold = detected result above the reporting detection limit.

Table B-5

TCE and PCE Detected in Groundwater and Seep Samples

2016 Annual Groundwater Monitoring Report
Palermo Wellfield Superfund Site
Tumwater, Washington

	Analyte	Tetrachloroethene	Trichloroethene
	ROD Remediation Goal	5	5
Location ID	Date	(µg/L)	(µg/L)
MW-100	5/12/2004	0.5 U	0.5 U
MW-100	9/21/2004	1 U	0.5 U
MW-100	4/26/2005	0.5 U	0.5 U
MW-100	10/5/2005	0.5 U	0.5 U
MW-100	3/16/2006	1 U	1 U
MW-100	10/30/2006	1 U	1 U
MW-100	6/6/2007	1 U	1 U
MW-100	11/12/2007	1 U	1 U
MW-100	5/19/2008	0.5 U	0.5 U
MW-100	10/27/2008	1 U	1 U
MW-100	4/27/2009	0.5 U	0.5 U
MW-100	11/9/2009	0.5 U	0.5 U
MW-100	5/19/2010	0.5 U	0.5 U
MW-100	10/19/2010	0.5 U	0.5 U
MW-100	5/23/2011	0.5 U	0.5 U
MW-100	11/8/2011	0.5 U	0.5 U
MW-100	5/29/2012	0.5 U	0.5 U
MW-100	3/5/2013	1 U	1 U
MW-100	9/19/2013	0.5 U	0.5 U
MW-100	4/15/2014	0.20 U	0.20 U
MW-100	8/20/2014	0.20 UJ	0.20 UJ
MW-100	3/10/2015	0.20 U	0.20 U
MW-100	8/26/2015	0.20 U	0.20 U
MW-100	4/19/2016	0.20 U	0.20 U
MW-100	8/30/2016	0.20 U	0.20 U
MW-101A	3/17/2006	1 U	1 U
MW-101A	5/29/2012	0.5 U	0.5 U
MW-101A	3/6/2013	1 U	1 U
MW-101A	9/17/2013	0.5 U	0.5 U
MW-101A	4/15/2014	0.20 U	0.20 U
MW-101A	8/21/2014	0.20 UJ	0.20 UJ
MW-101A	3/11/2015	0.20 U	0.20 U
MW-101A	8/26/2015	0.20 U	0.20 U
MW-101A	4/19/2016	0.20 U	0.20 U
MW-101A	8/30/2016	0.20 U	0.20 U
MW-101B	3/17/2006	**0.1 J**	**14**
MW-101B	10/31/2006	1 U	**6.2**
MW-101B	6/6/2007	1 U	**5.5**
MW-101B	11/13/2007	1 U	**5.7**
MW-101B	5/20/2008	0.5 U	**6.2**
MW-101B	10/28/2008	1 U	**3.9**
MW-101B	4/28/2009	0.5 U	**17**
MW-101B	11/10/2009	0.5 U	**2.2**
MW-101B	5/19/2010	0.5 U	**3.6**
MW-101B	10/21/2010	0.5 U	**3.3**
MW-101B	5/24/2011	0.5 U	**2.2**
MW-101B	11/8/2011	0.5 U	**3.7**
MW-101B	5/29/2012	0.5 U	**2.7**
MW-101B	3/5/2013	1 U	**3.0**
MW-101B	9/17/2013	0.5 U	**3.3**
MW-101B	4/15/2014	0.20 U	**2.9**
MW-101B	8/21/2014	0.20 UJ	**2.7 J**
MW-101B	3/11/2015	0.20 U	**2.7**
MW-101B	8/26/2015	0.20 U	**2.8**
MW-101B	4/19/2016	0.20 U	**2.8**
MW-101B	8/30/2016	0.20 U	**3.2**
MW-102	6/4/2012	0.5 U	0.5 U
MW-102	3/5/2013	1 U	1 U
MW-102	9/17/2013	0.5 U	0.5 U
MW-102	4/17/2014	0.20 U	0.20 U
MW-102	8/22/2014	0.20 UJ	0.20 UJ
MW-102	3/11/2015	0.20 U	0.20 U
MW-102	8/27/2015	0.20 U	0.20 U
MW-102	4/20/2016	0.20 U	0.20 U
MW-102	9/1/2016	0.20 U	0.20 U
MW-103	6/4/2012	0.5 U	0.5 U
MW-103	3/6/2013	1 U	1 U
MW-103	9/18/2013	0.5 U	0.5 U
MW-103	4/16/2014	0.20 U	0.20 U
MW-103	8/22/2014	0.20 UJ	0.20 UJ
MW-103	3/11/2015	0.20 U	0.20 U
MW-103	8/27/2015	0.20 U	0.20 U
MW-103	4/20/2016	0.20 U	0.20 U
MW-103	9/1/2016	0.20 U	0.20 U
MW-104A	3/17/2006	1 U	**6.6**
MW-104A	10/31/2006	1 U	**11**
MW-104A	6/4/2012	0.5 U	**5.3**
MW-104A	3/7/2013	1 U	**8.0**

	Analyte	Tetrachloroethene	Trichloroethene
	ROD Remediation Goal	5	5
Location ID	Date	(µg/L)	(µg/L)
MW-ES-07	10/28/2008	1 U	**6.9**
MW-ES-07	4/28/2009	0.5 U	**4.7**
MW-ES-07	11/10/2009	0.5 U	**3.6**
MW-ES-07	5/19/2010	0.5 U	**4.8**
MW-ES-07	10/21/2010	0.5 U	**5.1**
MW-ES-07	5/24/2011	0.5 U	**4.5**
MW-ES-07	11/8/2011	0.5 U	**9.7**
MW-ES-07	5/29/2012	0.5 U	**4.4**
MW-ES-07	3/5/2013	1 U	**3.9**
MW-ES-07	9/17/2013	0.5 U	**7.0**
MW-ES-07	4/15/2014	0.20 U	**4.3**
MW-ES-07	8/20/2014	0.20 UJ	**4.2 J**
MW-ES-07	3/11/2015	0.20 U	**3.8**
MW-ES-07	8/28/2015	0.20 U	**4.5**
MW-ES-07	4/19/2016	0.20 U	**4.6**
MW-ES-07	8/30/2016	0.20 U	**4.8**
MW-ES-08	5/29/2012	0.5 U	0.5 U
MW-ES-08	3/5/2013	1 U	1 U
MW-ES-08	9/19/2013	0.5 U	0.5 U
MW-ES-09	5/11/2004	0.5 U	**220**
MW-ES-09	9/22/2004	1 U	**200**
MW-ES-09	4/27/2005	0.5 U	**300**
MW-ES-09	10/6/2005	0.5 U	**120**
MW-ES-09	3/22/2006	1 U	**176**
MW-ES-09	11/2/2006	1 U	**170**
MW-ES-09	6/8/2007	1 U	**169**
MW-ES-09	11/14/2007	1 U	**160**
MW-ES-09	5/21/2008	0.5 U	**150**
MW-ES-09	10/29/2008	1 U	**150**
MW-ES-09	4/30/2009	5 U	**140**
MW-ES-09	11/11/2009	0.5 U	**73**
MW-ES-09	5/21/2010	0.5 U	**150**
MW-ES-09	10/22/2010	0.5 U	**130**
MW-ES-09	5/26/2011	0.5 U	**120**
MW-ES-09	11/9/2011	0.5 U	**150**
MW-ES-09	6/5/2012	0.5 U	**150 J**
MW-ES-09	3/11/2013	1 U	**120**
MW-ES-09	9/26/2013	1 U	**120**
MW-ES-09	4/21/2014	1.0 U	**110**
MW-ES-09	8/28/2014	0.40 U	**100**
MW-ES-09	3/16/2015	0.40 U	**99**
MW-ES-09	8/28/2015	0.20 U	**97**
MW-ES-09	4/22/2016	0.40 U	**86**
MW-ES-09	9/6/2016	0.40 U	**97**
MW-ES-10	5/11/2004	0.5 U	**83**
MW-ES-10	9/22/2004	1 U	**83**
MW-ES-10	4/27/2005	0.5 U	**78**
MW-ES-10	10/6/2005	0.5 U	**75**
MW-ES-10	3/22/2006	1 U	**65**
MW-ES-10	11/2/2006	1 U	**68**
MW-ES-10	6/8/2007	1 U	**63**
MW-ES-10	11/14/2007	1 U	**61**
MW-ES-10	5/21/2008	0.5 U	**46**
MW-ES-10	10/29/2008	1 U	**52**
MW-ES-10	4/30/2009	5 U	**34**
MW-ES-10	11/11/2009	0.5 U	**29**
MW-ES-10	5/21/2010	0.5 U	**53**
MW-ES-10	10/22/2010	0.5 U	**52**
MW-ES-10	5/26/2011	0.5 U	**36**
MW-ES-10	11/9/2011	0.5 U	**53**
MW-ES-10	6/5/2012	0.5 U	**67 J**
MW-ES-10	3/11/2013	1 U	**37**
MW-ES-10	9/26/2013	0.5 U	**36**
MW-ES-10	4/22/2014	0.20 U	**35**
MW-ES-10	8/28/2014	0.20 U	**32**
MW-ES-10	3/16/2015	0.20 U	**37**
MW-ES-10	8/31/2015	0.20 U	**32**
MW-ES-10	4/22/2016	0.20 U	**29**
MW-ES-10	9/6/2016	0.20 U	**31**
MW-ES-11	5/31/2012	0.5 U	0.5 U
MW-ES-11	3/6/2013	1 U	1 U
MW-ES-11	9/17/2013	0.5 U	0.5 U
MW-ES-11	4/17/2014	0.20 U	**0.22**
MW-ES-11	8/25/2014	0.20 UJ	**0.30 J**
MW-ES-11	3/17/2015	0.20 U	**0.33**
MW-ES-11	8/27/2015	0.20 U	**0.27**
MW-ES-11	4/20/2016	0.20 U	**0.31**
MW-ES-11	9/2/2016	0.20 U	**0.30**

Location ID	Date	Tetrachloroethene	Trichloroethene
	ROD Remediation Goal	5	5
		(µg/L)	(µg/L)
MW-104A	9/27/2013	0.5 U	4.6
MW-104A	4/18/2014	0.20 U	3.9
MW-104A	8/28/2014	0.20 U	4.5
MW-104A	3/12/2015	0.20 U	5.0
MW-104A	8/31/2015	0.20 U	4.0
MW-104A	4/22/2016	0.20 U	3.9
MW-104A	9/2/2016	0.20 U	4.2
MW-104B	5/11/2004	1.9	0.26 J
MW-104B	9/21/2004	1.6	0.5 U
MW-104B	4/26/2005	0.97	0.5 U
MW-104B	10/6/2005	0.09	0.5 U
MW-104B	3/16/2006	1.5	1 U
MW-104B	10/31/2006	1.7	1 U
MW-104B	6/7/2007	1.9	1 U
MW-104B	11/13/2007	2.4	1 U
MW-104B	5/20/2008	1.3	0.5 U
MW-104B	10/28/2008	1.6	1 U
MW-104B	4/29/2009	5 U	5 U
MW-104B	11/11/2009	0.87	0.5 U
MW-104B	5/20/2010	1.4	0.057 J
MW-104B	10/22/2010	1.8	0.5 U
MW-104B	5/26/2011	0.95	0.5 U
MW-104B	11/9/2011	1.6	0.5 U
MW-104B	6/4/2012	1.3	0.5 U
MW-104B	3/11/2013	1.4	1 U
MW-104B	9/27/2013	1.5	0.5 U
MW-104B	4/18/2014	0.99	0.20 U
MW-104B	8/28/2014	1.0	0.20 U
MW-104B	3/12/2015	1.1	0.20 U
MW-104B	8/31/2015	1.1	0.20 U
MW-104B	4/22/2016	0.82	0.20 U
MW-104B	9/2/2016	0.74	0.20 U
MW-107	6/7/2012	0.5 U	0.5 U
MW-107	3/6/2013	1 U	1 U
MW-107	9/20/2013	0.5 U	0.5 U
MW-107	4/18/2014	0.20 U	0.20 U
MW-107	8/27/2014	0.20 U	0.20 U
MW-107	3/13/2015	0.20 U	0.20 U
MW-107	8/28/2015	0.20 U	0.20 U
MW-107	4/21/2016	0.20 U	0.20 U
MW-107	9/1/2016	0.20 U	0.20 U
MW-109	5/12/2004	0.5 U	31
MW-109	9/21/2004	1 U	32
MW-109	4/26/2005	0.5 U	15
MW-109	10/5/2005	0.5 U	22
MW-109	3/20/2006	1 U	27
MW-109	11/1/2006	1 U	25
MW-109	6/7/2007	1 U	22
MW-109	11/13/2007	1 U	22
MW-109	5/20/2008	0.5 U	10
MW-109	10/28/2008	1 U	20
MW-109	4/28/2009	0.5 U	17
MW-109	11/10/2009	0.5 U	8.3
MW-109	5/19/2010	0.5 U	16
MW-109	10/21/2010	0.5 U	17
MW-109	5/24/2011	0.5 U	13
MW-109	11/8/2011	0.5 U	19
MW-109	5/30/2012	0.5 U	13
MW-109	3/5/2013	1 U	15
MW-109	9/18/2013	0.5 U	16
MW-109	4/16/2014	0.20 U	15
MW-109	8/21/2014	0.20 UJ	14 J
MW-109	3/10/2015	0.20 U	15
MW-109	8/28/2015	0.20 U	14
MW-109	4/19/2016	0.20 U	14
MW-109	8/30/2016	0.20 U	14
MW-110	5/12/2004	0.5 U	0.5 U
MW-110	9/21/2004	1 U	0.5 U
MW-110	4/26/2005	0.5 U	0.5 U
MW-110	10/5/2005	0.5 U	0.5 U
MW-110	3/15/2006	1 U	1U
MW-110	10/31/2006	1 U	1 U
MW-110	6/6/2007	1 U	1 U
MW-110	11/12/2007	1 U	1 U
MW-110	5/20/2008	0.5 U	0.5 U
MW-110	10/28/2008	1 U	1 U
MW-110	4/28/2009	0.5 U	0.5 U
MW-110	11/10/2009	0.5 U	0.5 U
MW-110	5/19/2010	0.5 U	0.5 U
MW-110	10/20/2010	0.5 U	0.5 U
MW-110	5/24/2011	0.5 U	0.5 U
MW-110	11/8/2011	0.5 U	0.5 U
MW-110	6/7/2012	0.5 U	0.5 U
MW-110	3/6/2013	1 U	1 U
MW-110	9/20/2013	0.5 U	0.5 U
MW-110	4/18/2014	0.20 U	0.20 U
MW-110	8/27/2014	0.20 U	0.20 U
MW-110	3/13/2015	0.20 U	0.20 U
MW-110	8/28/2015	0.20 U	0.20 U
MW-110	4/21/2016	0.20 U	0.20 U
MW-110	9/1/2016	0.20 U	0.20 U

Location ID	Date	Tetrachloroethene	Trichloroethene
	ROD Remediation Goal	5	5
		(µg/L)	(µg/L)
MW-UI	5/12/2004	0.5 U	21 J
MW-UI	9/21/2004	1 U	17
MW-UI	4/26/2005	0.5 U	8.8
MW-UI	10/5/2005	0.5 U	3.6
MW-UI	3/17/2006	1 U	5.2
MW-UI	10/31/2006	1 U	12
MW-UI	6/6/2007	1 U	23
MW-UI	11/12/2007	1 U	28
MW-UI	5/19/2008	0.5 U	16
MW-UI	10/28/2008	1 U	8.3
MW-UI	4/27/2009	0.5 U	7.9
MW-UI	11/10/2009	0.5 U	3.8
MW-UI	5/19/2010	0.5 U	7.8
MW-UI	10/19/2010	0.5 U	8.1
MW-UI	5/24/2011	0.5 U	11
MW-UI	11/8/2011	0.5 U	11
MW-UI	5/29/2012	0.5 U	9.3
MW-UI	3/5/2013	1 U	8.1
MW-UI	9/19/2013	0.5 U	6.6
MW-UI	4/15/2014	0.20 U	7.9
MW-UI	8/20/2014	0.20 UJ	7.3 J
MW-UI	3/10/2015	0.20 U	7.1
MW-UI	8/26/2015	0.20 U	4.1
MW-UI	4/19/2016	0.20 U	10
MW-UI	8/30/2016	0.20 U	7.5
PZ-704	6/6/2012	0.5 U	0.5 U
PZ-704	3/13/2013	1 U	1 U
PZ-704	9/23/2013	0.5 U	0.5 U
PZ-704	4/21/2014	0.20 U	0.20 U
PZ-709	6/6/2012	0.5 U	0.5 U
PZ-709	3/13/2013	1 U	1 U
PZ-709	9/23/2013	0.2 UJ	0.2 UJ
PZ-709	4/21/2014	0.20 U	0.20 U
PZ-715	6/6/2012	0.5 U	0.5 U
PZ-715	3/13/2013	1 U	1 U
PZ-715	9/23/2013	0.5 U	0.5 U
PZ-715	4/21/2014	0.20 U	0.20 U
PZ-719	6/6/2012	0.5 U	1.7
PZ-719	3/14/2013	1 U	1.6
PZ-719	9/24/2013	0.5 U	2.1
PZ-719	1/28/2014	0.20 U	2.0
PZ-719	4/18/2014	0.20 U	1.8
PZ-719	8/18/2014	0.20 UJ	1.5 J
PZ-719	3/16/2015	0.20 U	2.1
PZ-719	8/24/2015	0.20 U	2.1
PZ-719	4/28/2016	0.20 U	2.2
PZ-719	9/7/2016	0.20 U	2.5
PZ-720	2/1/2004	1.1	17
PZ-720	6/6/2012	0.5 U	6.6 J
PZ-720	3/14/2013	0.38 J	5.0
PZ-720	9/24/2013	0.55	9.7
PZ-720	1/29/2014	0.51	6.7
PZ-720	4/18/2014	0.40	5.5
PZ-720	8/19/2014	0.94	16
PZ-720	3/16/2015	0.52	12
PZ-720	8/24/2015	0.82	18
PZ-720	4/28/2016	0.49	9.9
PZ-720	9/7/2016	0.78	16
PZ-721	2/1/2004	0.79	98
PZ-721	3/15/2006	0.40 J	47
PZ-721	11/2/2006	0.69 J	59
PZ-721	6/5/2007	1 U	35
PZ-721	11/14/2007	0.53 J	52
PZ-721	5/21/2008	0.39 J	41
PZ-721	10/27/2008	1 U	19
PZ-721	4/30/2009	5 U	35
PZ-721	11/11/2009	0.5 U	27
PZ-721	5/19/2010	0.20 J	41
PZ-721	10/20/2010	0.5 U	48
PZ-721	5/26/2011	0.5 U	30
PZ-721	11/10/2011	0.5 U	44
PZ-721	6/6/2012	0.5 U	38
PZ-721	3/14/2013	1 U	30
PZ-721	9/24/2013	0.5 U	54
PZ-721	1/29/2014	0.20 U	34
PZ-721	4/22/2014	0.20 U	37
PZ-721	8/19/2014	0.40 U	61
PZ-721	3/16/2015	0.20 U	42
PZ-721	8/24/2015	0.29	49
PZ-721	4/28/2016	0.20 U	34
PZ-721	9/7/2016	0.21	37
PZ-722	6/6/2012	0.5 U	0.5 U
PZ-722	3/14/2013	1 U	1 U
PZ-722	9/25/2013	0.5 U	0.5 U
PZ-722	1/29/2014	0.20 U	0.20 U
PZ-722	4/22/2014	0.20 U	0.20 U
PZ-722	8/19/2014	0.20 U	0.20 U
PZ-722	3/17/2015	0.20 U	0.20 U
PZ-722	8/24/2015	0.20 U	0.20 U
PZ-723	6/6/2012	0.5 U	0.5 U
PZ-723	3/14/2013	1 U	1 U

	Analyte	Tetrachloroethene	Trichloroethene
	ROD Remediation Goal	5	5
Location ID	Date	(µg/L)	(µg/L)
MW-111	5/12/2004	0.5 U	22
MW-111	9/21/2004	1 U	17
MW-111	4/26/2005	0.5 U	0.5 U
MW-111	10/5/2005	0.5 U	12
MW-111	3/17/2006	1 U	20
MW-111	11/1/2006	1 U	16
MW-111	6/6/2007	1 U	18
MW-111	11/13/2007	1 U	16
MW-111	5/20/2008	0.5 U	14
MW-111	10/28/2008	1 U	17
MW-111	4/28/2009	0.5 U	11
MW-111	11/10/2009	0.5 U	5.8
MW-111	5/19/2010	0.5 U	12
MW-111	10/21/2010	0.5 U	11
MW-111	5/24/2011	0.5 U	12
MW-111	11/8/2011	0.5 U	13
MW-111	5/30/2012	0.5 U	12
MW-111	3/7/2013	1 U	9.1
MW-111	9/19/2013	0.5 U	9.2
MW-111	4/16/2014	0.20 U	8.4
MW-111	8/22/2014	0.20 UJ	7.7 J
MW-111	3/11/2015	0.20 U	8.8
MW-111	8/27/2015	0.20 U	8.5
MW-111	4/21/2016	0.20 U	8.3
MW-111	8/31/2016	0.20 U	7.1
MW-4A	3/20/2006	1 U	1 U
MW-4A	6/5/2012	0.5 U	0.5 U
MW-4A	3/12/2013	1 U	1 U
MW-4A	9/26/2013	0.5 U	0.5 U
MW-4A	4/22/2014	0.20 U	0.20 U
MW-4A	8/28/2014	0.20 U	0.20 U
MW-4A	3/13/2015	0.20 U	0.20 U
MW-4A	8/28/2015	0.20 U	0.20 U
MW-4A	4/20/2016	0.20 U	0.20 U
MW-4A	8/31/2016	0.20 U	0.20 U
MW-4B	3/20/2006	1 U	1 U
MW-4B	6/5/2012	0.5 U	0.5 U
MW-4B	3/12/2013	1 U	1 U
MW-4B	9/26/2013	0.5 U	0.5 U
MW-4B	4/22/2014	0.20 U	0.20 U
MW-4B	8/28/2014	0.20 U	0.20 U
MW-4B	3/13/2015	0.20 U	0.20 U
MW-4B	8/28/2015	0.20 U	0.20 U
MW-4B	4/20/2016	0.20 U	0.20 U
MW-4B	8/31/2016	0.20 U	0.20 U
MW-93-02	6/5/2012	0.5 U	0.5 U
MW-93-02	3/12/2013	1 U	1 U
MW-93-02	9/20/2013	0.5 U	0.5 U
MW-93-02	4/17/2014	0.20 U	0.20 U
MW-93-02	8/28/2014	0.20 U	0.20 U
MW-93-02	3/13/2015	0.20 U	0.20 U
MW-93-02	9/1/2015	0.20 U	0.20 U
MW-93-02	4/21/2016	0.20 U	0.20 U
MW-93-02	9/1/2016	0.20 U	0.20 U
MW-96-15	5/30/2012	0.5 U	0.5 U
MW-96-15	3/7/2013	1 U	1 U
MW-96-15	9/17/2013	0.5 U	0.5 U
MW-96-15	4/17/2014	0.20 U	0.20 U
MW-96-15	8/26/2014	0.20 U	0.20 U
MW-96-15	3/17/2015	0.20 U	0.20 U
MW-96-15	9/1/2015	0.20 U	0.20 U
MW-96-15	4/20/2016	0.20 U	0.20 U
MW-96-15	8/31/2016	0.20 U	0.20 U
MW-96-16	6/5/2012	0.5 U	0.5 U
MW-96-16	3/6/2013	1 U	1 U
MW-96-16	9/18/2013	0.5 U	0.5 U
MW-96-16	4/16/2014	0.20 U	0.20 U
MW-96-16	8/26/2014	0.20 U	0.20 U
MW-96-16	3/17/2015	0.20 U	0.20 U
MW-96-16	9/1/2015	0.20 U	0.20 U
MW-96-16	4/21/2016	0.20 U	0.20 U
MW-96-16	9/2/2016	0.20 U	0.20 U
MW-96-17	6/5/2012	0.5 U	0.5 U
MW-96-17	3/6/2013	1 U	1 U
MW-96-17	9/18/2013	0.5 U	0.5 U
MW-96-17	4/15/2014	0.20 U	0.20 U
MW-96-17	8/26/2014	0.20 U	0.20 U
MW-96-17	3/13/2015	0.20 U	0.20 U
MW-96-17	9/1/2015	0.20 U	0.20 U
MW-96-17	4/21/2016	0.20 U	0.20 U
MW-96-17	9/1/2016	0.20 U	0.20 U
MW-ES-02	3/22/2006	1 U	56
MW-ES-02	11/1/2006	1 U	68
MW-ES-02	6/7/2007	1 U	66
MW-ES-02	11/14/2007	1 U	66
MW-ES-02	5/20/2008	0.5 U	47

	Analyte	Tetrachloroethene	Trichloroethene
	ROD Remediation Goal	5	5
Location ID	Date	(µg/L)	(µg/L)
PZ-723	9/25/2013	0.5 U	0.5 U
PZ-723	1/28/2014	0.20 U	0.20 U
PZ-723	4/23/2014	0.20 U	0.20 U
PZ-723	8/18/2014	0.20 UJ	0.20 UJ
PZ-723	3/17/2015	0.20 U	0.20 U
PZ-723	8/25/2015	0.20 U	0.20 U
PZ-723	4/27/2016	0.20 U	0.20 U
PZ-723	9/6/2016	0.20 U	0.20 U
PZ-724	2/1/2004	0.45 J	39
PZ-724	3/15/2006	0.3 J	28
PZ-724	11/2/2006	1 U	37
PZ-724	6/5/2007	1 U	15
PZ-724	11/14/2007	1 U	32
PZ-724	5/21/2008	0.22 J	87
PZ-724	10/27/2008	1 U	44
PZ-724	4/30/2009	5 U	35
PZ-724	11/11/2009	0.5 U	28
PZ-724	5/19/2010	0.5 U	34
PZ-724	10/20/2010	0.5 U	43
PZ-724	5/26/2011	0.5 U	30
PZ-724	11/10/2011	0.5 U	53
PZ-724	6/7/2012	0.5 U	13
PZ-724	3/14/2013	1 U	32
PZ-724	9/25/2013	0.5 U	43
PZ-724	1/29/2014	0.20 U	40
PZ-724	4/22/2014	0.20 U	29
PZ-724	8/19/2014	0.20 U	41
PZ-724	3/16/2015	0.20 U	34
PZ-724	8/24/2015	0.20 U	47
PZ-724	4/28/2016	0.20 U	23
PZ-724	9/7/2016	0.20 U	49
PZ-725	2/1/2004	0.5 U	0.35 J
PZ-725	6/8/2012	0.5 U	0.5 U
PZ-725	3/14/2013	1 U	1 U
PZ-725	9/24/2013	0.5 U	0.5 U
PZ-725	1/29/2014	0.20 U	0.20 U
PZ-725	4/22/2014	0.20 U	0.20 U
PZ-725	8/19/2014	0.20 U	0.20 U
PZ-725	3/17/2015	0.20 U	0.20 U
PZ-725	8/24/2015	0.20 U	0.20 U
PZ-725	4/28/2016	0.20 U	0.20 U
PZ-725	9/7/2016	0.20 U	0.23
PZ-726	2/1/2004	0.5 U	3.1
PZ-726	6/8/2012	0.5 U	3.4 J
PZ-726	3/12/2013	1 U	2.7
PZ-726	9/25/2013	0.5 U	3.8
PZ-726	1/28/2014	0.20 U	3.2
PZ-726	4/23/2014	0.20 U	3.1
PZ-726	8/18/2014	0.20 UJ	3.6 J
PZ-726	3/17/2015	0.20 U	3.7
PZ-726	8/25/2015	0.20 U	3.7
PZ-726	4/27/2016	0.20 U	3.4
PZ-726	9/6/2016	0.20 U	3.9
PZ-728	2/1/2004	0.5 U	31
PZ-728	3/15/2006	1 U	24
PZ-728	11/2/2006	1 U	16
PZ-728	6/5/2007	1 U	18
PZ-728	11/14/2007	1 U	21
PZ-728	5/21/2008	0.5 U	14
PZ-728	10/27/2008	1 U	51
PZ-728	4/30/2009	5 U	9.1
PZ-728	11/11/2009	0.5 U	8.2
PZ-728	5/19/2010	0.5 U	10
PZ-728	10/20/2010	0.5 U	12
PZ-728	5/26/2011	0.5 U	6.0
PZ-728	11/10/2011	0.5 U	7.7
PZ-728	6/8/2012	0.5 U	4.5 J
PZ-728	3/7/2013	1 U	4.7
PZ-728	9/25/2013	0.5 U	5.1
PZ-728	1/29/2014	0.20 U	4.2
PZ-728	4/23/2014	0.20 U	4.2
PZ-728	8/18/2014	0.20 UJ	4.0 J
PZ-728	3/16/2015	0.20 U	4.9
PZ-728	8/25/2015	0.20 U	3.9
PZ-728	4/27/2016	0.20 U	3.8
PZ-728	9/6/2016	0.20 U	4.0
RPZ-730	6/4/2012	0.5 U	0.5 U
RPZ-730	3/13/2013	1 U	1 U
RPZ-730	9/24/2013	0.5 U	0.5 U
RPZ-730	1/28/2014	0.20 U	0.20 U
RPZ-730	4/23/2014	0.20 U	0.20 U
RPZ-730	8/18/2014	0.20 UJ	0.20 UJ
RPZ-730	3/17/2015	0.20 U	0.20 U
RPZ-730	8/25/2015	0.20 U	0.20 U
RPZ-730	4/27/2016	0.20 U	0.20 U
RPZ-730	9/6/2016	0.20 U	0.20 U

	Analyte	Tetrachloroethene	Trichloroethene
	ROD Remediation Goal	5	5
Location ID	Date	(µg/L)	(µg/L)
MW-ES-02	10/29/2008	1 U	50
MW-ES-02	4/29/2009	5 U	43
MW-ES-02	11/11/2009	0.5 U	29
MW-ES-02	5/20/2010	0.5 U	53
MW-ES-02	10/22/2010	0.5 U	58
MW-ES-02	5/26/2011	0.5 U	46
MW-ES-02	11/8/2011	0.5 U	51
MW-ES-02	5/31/2012	0.5 U	47
MW-ES-02	3/7/2013	1 U	38
MW-ES-02	9/20/2013	0.5 U	39
MW-ES-02	4/21/2014	0.20 U	39
MW-ES-02	8/27/2014	0.20 U	34
MW-ES-02	3/11/2015	0.20 U	40
MW-ES-02	8/28/2015	0.20 U	40
MW-ES-02	4/22/2016	0.20 U	36
MW-ES-02	8/31/2016	0.20 U	34
MW-ES-03	5/11/2004	0.5 U	37
MW-ES-03	9/22/2004	1 U	42
MW-ES-03	4/27/2005	0.5 U	22
MW-ES-03	10/6/2005	0.13 J	22
MW-ES-03	3/20/2006	1 U	27
MW-ES-03	11/1/2006	1 U	22
MW-ES-03	6/7/2007	1 U	26
MW-ES-03	11/14/2007	1 U	26
MW-ES-03	5/21/2008	0.5 U	24
MW-ES-03	10/29/2008	1 U	25
MW-ES-03	4/29/2009	5 U	16
MW-ES-03	11/12/2009	0.5 U	12
MW-ES-03	5/20/2010	0.5 U	21
MW-ES-03	10/21/2010	0.5 U	25
MW-ES-03	5/25/2011	0.5 U	21
MW-ES-03	11/9/2011	0.5 U	27
MW-ES-03	6/4/2012	0.5 U	21
MW-ES-03	3/7/2013	1 U	17
MW-ES-03	9/19/2013	0.5 U	18
MW-ES-03	4/17/2014	0.20 U	16
MW-ES-03	8/27/2014	0.20 U	14
MW-ES-03	3/12/2015	0.20 U	16
MW-ES-03	8/31/2015	0.20 U	14
MW-ES-03	4/21/2016	0.20 U	15
MW-ES-04	5/11/2004	58	0.52
MW-ES-04	9/22/2004	52	0.44 J
MW-ES-04	4/27/2005	51	0.35 J
MW-ES-04	10/6/2005	38	0.24 J
MW-ES-04	3/20/2006	48	0.8 J
MW-ES-04	11/1/2006	43	1.2
MW-ES-04	6/7/2007	35	1.2
MW-ES-04	11/14/2007	38	1.7
MW-ES-04	5/21/2008	49	1.8
MW-ES-04	10/29/2008	25	1.1
MW-ES-04	4/29/2009	21	0.56 J
MW-ES-04	11/12/2009	16	0.38 J
MW-ES-04	5/20/2010	42	0.64 J
MW-ES-04	10/21/2010	34	0.60
MW-ES-04	5/25/2011	23	0.52
MW-ES-04	11/9/2011	26	0.75
MW-ES-04	6/4/2012	31	0.82
MW-ES-04	3/8/2013	44	0.56 J
MW-ES-04	9/19/2013	32	0.5 U
MW-ES-04	4/17/2014	34	0.31
MW-ES-04	8/27/2014	16	0.20 U
MW-ES-04	3/12/2015	33	0.26
MW-ES-04	8/31/2015	36	0.21
MW-ES-04	4/21/2016	27	0.22
MW-ES-05	5/11/2004	0.5 U	46 J
MW-ES-05	9/22/2004	1 U	44
MW-ES-05	4/26/2005	0.5 U	52
MW-ES-05	10/5/2005	0.5 U	37
MW-ES-05	3/21/2006	1 U	46
MW-ES-05	11/1/2006	1 U	58
MW-ES-05	6/7/2007	1 U	54
MW-ES-05	11/13/2007	1 U	53
MW-ES-05	5/21/2008	0.21 J	58
MW-ES-05	10/29/2008	1 U	41
MW-ES-05	4/29/2009	5 U	27
MW-ES-05	11/11/2009	0.5 U	16
MW-ES-05	5/20/2010	0.5 U	33
MW-ES-05	10/22/2010	0.5 U	36
MW-ES-05	5/25/2011	0.5 U	30
MW-ES-05	11/9/2011	0.5 U	35
MW-ES-05	5/30/2012	0.5 U	32
MW-ES-05	3/8/2013	1 U	27
MW-ES-05	9/20/2013	0.5 U	27
MW-ES-05	4/21/2014	0.20 U	25
MW-ES-05	8/27/2014	0.20 U	24
MW-ES-05	3/12/2015	0.20 U	26
MW-ES-05	8/28/2015	0.20 U	24
MW-ES-05	4/22/2016	0.20 U	25
MW-ES-05	8/31/2016	0.20 U	26
MW-ES-06	5/11/2004	31	11

	Analyte	Tetrachloroethene	Trichloroethene
	ROD Remediation Goal	5	5
Location ID	Date	(µg/L)	(µg/L)
RPZ-731	6/4/2012	0.5 U	0.61
RPZ-731	3/13/2013	1 U	0.60 J
RPZ-731	9/24/2013	0.5 U	1.6
RPZ-731	1/29/2014	0.20 U	0.64
RPZ-731	4/23/2014	0.20 U	0.65
RPZ-731	8/19/2014	0.20 U	1.6
RPZ-731	3/17/2015	0.20 U	0.75
RPZ-731	8/25/2015	0.20 U	2.1
RPZ-731	4/27/2016	0.20 U	0.95
RPZ-731	9/6/2016	0.20 U	2.8
RPZ-732	6/5/2012	0.5 U	0.5 U
RPZ-732	3/12/2013	1 U	1 U
RPZ-732	9/24/2013	0.5 U	0.5 U
RPZ-732	1/29/2014	0.20 U	0.20 U
RPZ-732	4/22/2014	0.23	0.20 U
RPZ-732	8/19/2014	0.29	0.20 U
RPZ-732	3/16/2015	0.36	0.20 U
RPZ-732	8/25/2015	0.37	0.20 U
RPZ-732	4/27/2016	0.50	0.20 U
RPZ-732	9/6/2016	0.45	0.20 U
Seep 1	5/30/2012	0.5 U	0.5 U
Seep 1	3/19/2013	1 U	1 U
Seep 1	10/2/2013	0.5 U	0.5 U
Seep 1	4/21/2014	0.20 U	0.20 U
Seep 2	5/30/2012	0.5 U	0.5 U
Seep 2	3/19/2013	1 U	1 U
Seep 2	10/2/2013	0.5 U	0.5 U
Seep 2	4/21/2014	0.20 U	0.20 U
Seep 3	5/31/2012	0.5 U	0.5 U
Seep 3	3/19/2013	1 U	1 U
Seep 3	10/2/2013	0.5 U	0.5 U
Seep 3	4/21/2014	0.20 U	0.20 U
Seep 5	5/31/2012	0.5 U	0.5 U
Seep 5	5/31/2012	0.5 U	0.5 U
Seep 5	3/19/2013	1 U	1 U
Seep 5	10/2/2013	0.5 U	0.5 U
Seep 5	4/21/2014	0.20 U	0.20 U
ST-1	6/5/2007	1.0 U	1.0 U
ST-1	11/14/2007	1.0 U	1.0 U
ST-1	5/21/2008	0.5 U	0.5 U
ST-1	10/29/2008	1.0 U	1.0 U
ST-1	5/23/2011	0.5 U	0.5 U
ST-1	11/7/2011	0.5 U	0.5 U
ST-1	4/18/2014	0.20 U	0.20 U
ST-1	8/25/2014	0.20 U	0.20 U
ST-2	6/5/2007	1.0 U	1.0 U
ST-2	11/14/2007	1.0 U	1.0 U
ST-2	5/21/2008	0.5 U	0.5 U
ST-2	4/29/2009	0.5 U	0.5 U
ST-2	11/10/2009	0.5 U	0.5 U
ST-2	5/18/2010	0.5 U	0.5 U
ST-2	10/20/2010	0.5 U	0.5 U
ST-2	6/11/2012	0.5 U	0.5 U
ST-2	3/7/2013	1.0 U	1.0 U
ST-2	9/18/2013	0.5 U	0.5 U
ST-2	9/6/2016	0.20 U	0.20 U
TW-4	3/15/2006	1.0 U	3.4
TW-4	11/2/2006	1.0 U	2.1
TW-4	6/4/2007	1.0 U	3.3
TW-4	11/14/2007	1.0 U	2.2
TW-4	5/21/2008	0.5 U	0.61
TW-4	10/29/2008	1.0 U	1.3
TW-4	4/30/2009	0.5 U	1.3
TW-4	11/10/2009	0.5 U	0.85
TW-4	5/18/2010	0.5 U	1.1
TW-4	10/20/2010	0.5 U	0.76
TW-4	5/23/2011	0.5 U	0.5 U
TW-4	11/7/2011	0.5 U	0.5 U
TW-4	6/11/2012	0.5 U	0.71 J
TW-4	3/7/2013	1.0 U	1.7
TW-4	9/18/2013	0.5 U	1.3
TW-4	4/18/2014	0.20 U	0.43
TW-4	8/25/2014	0.20 U	0.89
TW-4	3/16/2015	0.20 U	0.20 U
TW-4	9/6/2016	0.20 U	0.60
TW-5	3/15/2006	1.0 U	7.4
TW-5	11/2/2006	1.0 U	6.5
TW-5	6/5/2007	1.0 U	10
TW-5	11/14/2007	1.0 U	8.4
TW-5	5/21/2008	0.5 U	3.8
TW-5	10/29/2008	1.0 U	3.7
TW-5	4/29/2009	0.5 U	2.5
TW-5	11/10/2009	0.5 U	1.1
TW-5	5/18/2010	0.5 U	1.2
TW-5	10/20/2010	0.5 U	0.5 U
TW-5	5/23/2011	0.5 U	0.5 U
TW-5	11/7/2011	0.5 U	0.5 U
TW-5	6/11/2012	0.5 U	0.5 U
TW-5	3/7/2013	1.0 U	1.0 U
TW-5	9/18/2013	0.5 U	0.5 U

	Analyte	Tetrachloroethene	Trichloroethene
	ROD Remediation Goal	5	5
Location ID	Date	(µg/L)	(µg/L)
MW-ES-06	9/22/2004	**26**	**11**
MW-ES-06	4/26/2005	**15**	**4.6**
MW-ES-06	10/5/2005	**19**	**11**
MW-ES-06	3/21/2006	**25**	**16**
MW-ES-06	11/1/2006	**34**	**12**
MW-ES-06	6/7/2007	**49**	**6.1**
MW-ES-06	11/13/2007	**40**	**6.9**
MW-ES-06	5/21/2008	**16**	**4.7**
MW-ES-06	10/29/2008	**18**	**5.7**
MW-ES-06	4/29/2009	**16**	5 U
MW-ES-06	11/11/2009	**11**	**2.3**
MW-ES-06	5/20/2010	**18**	**3.1**
MW-ES-06	10/22/2010	**14**	**2.7**
MW-ES-06	5/25/2011	**26**	**1.2**
MW-ES-06	11/9/2011	**36**	**1.6**
MW-ES-06	5/30/2012	**34**	**1.2**
MW-ES-06	3/8/2013	**23**	**0.97 J**
MW-ES-06	9/20/2013	**27**	**0.76**
MW-ES-06	4/21/2014	**13**	**1.1**
MW-ES-06	8/28/2014	**15**	**0.71**
MW-ES-06	3/12/2015	**13**	**0.95**
MW-ES-06	8/28/2015	**21**	**0.57**
MW-ES-06	4/22/2016	**29**	0.20 U
MW-ES-06	8/31/2016	**21**	**0.46**
MW-ES-07	3/20/2006	**0.1 J**	**7.8**
MW-ES-07	10/31/2006	1 U	**11**
MW-ES-07	6/6/2007	1 U	**10**
MW-ES-07	11/13/2007	1 U	**11**
MW-ES-07	5/20/2008	0.5 U	**8.6**

Notes:

µg/L = microgram per liter

J = estimated result

U = not detected at or above the reporting limit

Bold font type indicates the analyte was detected above the reporting limit.

Gray shading indicates the analyte was detected above the ROD Remediation Goal.

Samples were also analyzed for 1,1-DCE, trans-1,2-DCE, cis-1,2-DCE and vinyl chloride.

	Analyte	Tetrachloroethene	Trichloroethene
	ROD Remediation Goal	5	5
Location ID	Date	(µg/L)	(µg/L)
TW-8	6/11/2012	0.5 U	0.5 U
TW-8	3/7/2013	1.0 U	1.0 U
TW-8	9/18/2013	0.5 U	0.5 U
TW-8	4/18/2014	0.20 U	0.20 U
TW-8	8/25/2014	0.20 U	0.20 U
TW-8	3/16/2015	0.20 U	0.20 U
TW-8	9/6/2016	0.20 U	0.20 U
TW-16	4/18/2014	0.20 U	**9.6**
TW-16	8/27/2014	0.20 U	**19**
TW-16	3/16/2015	0.20 U	**10**
WDOT-MW-1	5/31/2012	0.5 U	0.5 U
WDOT-MW-1	3/7/2013	1 U	1 U
WDOT-MW-1	9/18/2013	0.5 U	0.5 U
WDOT-MW-1	4/16/2014	0.20 U	0.20 U
WDOT-MW-1	8/25/2014	0.20 UJ	0.20 UJ
WDOT-MW-1	3/12/2015	0.20 U	0.20 U
WDOT-MW-1	8/27/2015	0.20 U	0.20 U
WDOT-MW-1	4/20/2016	0.20 U	0.20 U
WDOT-MW-1	9/2/2016	0.20 U	0.20 U
WDOT-MW-2	5/31/2012	0.5 U	0.5 U
WDOT-MW-2	3/6/2013	1 U	1 U
WDOT-MW-2	9/18/2013	0.5 U	0.5 U
WDOT-MW-2	4/16/2014	0.20 U	0.20 U
WDOT-MW-2	8/25/2014	0.20 UJ	0.20 UJ
WDOT-MW-2	3/12/2015	0.20 U	0.20 U
WDOT-MW-2	8/27/2015	0.20 U	0.20 U
WDOT-MW-2	4/20/2016	0.20 U	0.20 U
WDOT-MW-2	9/2/2016	0.20 U	0.20 U

APPENDIX C
Data Validation Reports

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Data Validation Report

Project: Palermo Wellfield Remedial Investigation and Feasibility Study
April 2016 Semiannual Groundwater Monitoring and Subdrain System Sampling

GEI File No: 0180-121-11

Date: May 19, 2016

This report documents the results of a United States Environmental Protection Agency (USEPA)-defined Stage 2B data validation (USEPA Document 540-R-08-005; USEPA 2009) of analytical data from the analyses of water samples collected as part of the April 2016 Semiannual Groundwater and Subdrain System sampling events, and the associated laboratory and field quality control (QC) samples. The samples were obtained from the Palermo Wellfield Superfund Site located in Tumwater, Washington.

OBJECTIVE AND QUALITY CONTROL ELEMENTS

GeoEngineers, Inc. (GeoEngineers) completed the data validation consistent with USEPA Contract Laboratory Program National Functional Guidelines for Superfund Organic Methods Data Review (USEPA 2014) (National Functional Guidelines) to determine if the laboratory analytical results meet the project objectives and are usable for their intended purpose. Data usability was assessed by determining if:

- The samples were analyzed using well-defined and acceptable methods that provide reporting limits below applicable regulatory criteria;
- The precision and accuracy of the data are well-defined and sufficient to provide defensible data; and
- The quality assurance/quality control (QA/QC) procedures utilized by the laboratory meet acceptable industry practices and standards.

In accordance with the Field Sampling Plan, Semiannual Groundwater Monitoring (GeoEngineers 2013a) and Quality Assurance Project Plan Subdrain System and Treatment Lagoon Sampling (GeoEngineers 2013b), the data validation included review of the following QC elements:

- Data Package Completeness
- Chain-of-Custody Documentation
- Holding Times and Sample Preservation
- Surrogate Recoveries
- Method, Trip, and Rinsate Blanks
- Matrix Spikes/Matrix Spike Duplicates
- Laboratory Control Samples/Laboratory Control Sample Duplicates
- Field Duplicates (FDs)
- Internal Standards

- Initial Calibrations (ICALs)
- Continuing Calibrations (CCALs)
- Reporting Limits

VALIDATED SAMPLE DELIVERY GROUPS

This data validation included review of the sample delivery groups (SDGs) listed below in Table 1.

TABLE 1. SUMMARY OF VALIDATED SAMPLE DELIVERY GROUPS

Laboratory SDG	Samples Validated
1604-158	MW-100-160419, MW-ES-07-160419, DUP-2-160419, MW-UI-160419, RB-2-160419, TB-2-160419
1604-159	MW-101A-160419, DUP-1-160419, MW-101B-160419, MW-109-160419, RB-1-160419, TB-1-160419
1604-170	MW-103-160420, MW-ES-11-160420, WDOT-MW-1-160420, WDOT-MW-2-160420, RB-1-160420, TB-1-160420
1604-171	MW-4A-160420, MW-4B-160420, MW-96-15-160420, MW-102-160420, RB-2-160420, TB-2-160420
1604-181	MW-93-02-160421, MW-107-160421, MW-110-160421, MW-ES-03-160421, RB-1-160421, TB-1-160421
1604-182	MW-96-16-160421, MW-96-17-160421, MW-111-160421, MW-ES-04-160421, RB-2-160421, TB-2-160421
1604-202	MW-ES-02-160422, MW-ES-05-160422, MW-ES-06-160422, RB-1-160422, TB-1-160422
1604-203	MW-104A-160422, MW-104B-160422, DUP-2-160422, MW-ES-09-160422, MW-ES-10-160422, RB-2-160422, TB-2-160422
1604-230	350-160426, 356-160426, 357-160426, DUP-1-160426, 358-160426, 359-160426, 360-160426, 361-160426, 364-160426, RB-1-160426, TB-1-160426
1604-246	PZ-723-160427, PZ-726-160427, PZ-728-160427, RPZ-730-160427, RPZ-731-160427, RPZ-732-160427, TB-2-160427
1604-256	PZ-719-160428, PZ-720-160428, PZ-721-160428, PZ-724-160428, PZ-725-160428, DUP-2-160428, TB-2-160428

CHEMICAL ANALYSIS PERFORMED

OnSite Environmental, Inc. (OnSite), located in Redmond, Washington, performed laboratory analysis on the water samples using the following method:

- Volatile organic compounds (VOCs) by Method SW8260C

DATA VALIDATION SUMMARY

The results for each of the QC elements are summarized below.

Data Package Completeness

OnSite provided all required deliverables for the data validation according to the National Functional Guidelines. The laboratory followed adequate corrective action processes and all identified anomalies were discussed in the relevant laboratory case narrative.

Chain-of-Custody Documentation

Chain-of-custody (COC) forms were provided with the laboratory analytical reports. The COCs were accurate and complete when submitted to the laboratory with the exception identified below.

SDG 1604-159: The laboratory noted that for Sample RB-1-160419 the COC lists two sample vials; however, three sample vials were received.

Holding Times and Sample Preservation

The sample holding time is defined as the time that elapses between sample collection and sample analysis. Maximum holding time criteria exist for each analysis to help ensure that the analyte concentrations found at the time of analysis reflect the concentration present at the time of sample collection. Established holding times were met for all analyses. The samples within all cooler containers were properly protected with bubble wrap, preserved with wet ice and arrived at the laboratory at the appropriate temperatures of between two and six degrees Celsius, with one exception where the temperature was slightly below the lower limit, but above freezing. The out-of-compliance temperature is detailed below.

SDG 1604-256: The sample cooler temperature recorded at the laboratory was one degree Celsius. It was determined through professional judgment that since the samples were not frozen, this temperature should not affect the sample analytical results.

Surrogate Recoveries

A surrogate compound is a compound that is chemically similar to the organic analytes of interest, but unlikely to be found in any environmental sample. Surrogates are used for organic analyses and are added to all samples, standards, and blanks to serve as an accuracy and specificity check of each analysis. The surrogates are added to the samples at a known concentration and percent recoveries are calculated following analysis. All surrogate percent recoveries for field samples were within the laboratory control limits.

Method, Trip, and Rinsate Blanks

Method blanks are analyzed to ensure that laboratory procedures and reagents do not introduce measurable concentrations of the analytes of interest. A method blank was analyzed with each batch of samples, at a frequency of 1 per 20 samples. For all sample batches, method blanks were analyzed at the required frequency. None of the analytes of interest were detected above the reporting limits in any of the method blanks.

Trip blanks are analyzed to provide an indication as to whether volatile compounds have cross-contaminated other like samples within the transportation process to the laboratory. Eleven (11) trip blanks were collected (one for each cooler): TB-1-160419, TB-2-160419, TB-1-160420, TB-2-160420, TB-1-160421, TB-2-160421, TB-1-160422, TB-2-160422, TB-1-160426, TB-2-160427, and TB-2-160428. None of the analytes of interest were detected above the reporting limits in any of the trip blanks.

Equipment rinsate blanks are analyzed to provide an indication as to whether field decontamination and sampling procedures effectively prevent cross-contamination in field activities. Nine (9) equipment rinsate blanks were collected: RB-1-160419, RB-2-160419, RB-1-160420, RB-2-160420, RB-1-160421, RB-2-160421, RB-1-160422, RB-2-160422, and RB-1-160426. None of the analytes of interest were detected above the reporting limits in any of the rinsate blanks.

Matrix Spikes/Matrix Spike Duplicates

Since the actual analyte concentration in an environmental sample is not known, the accuracy of a particular analysis is usually inferred by performing a matrix spike (MS) analysis on one sample from the associated batch, known as the parent sample. One aliquot of the sample is analyzed in the normal manner and then a second aliquot of the sample is spiked with a known amount of analyte concentration and analyzed. From these analyses, a percent recovery is calculated. Matrix spike duplicate (MSD) analyses are generally performed for organic analyses as a precision check and analyzed in the same sequence as a matrix spike. Using the result values from the MS and MSD, the relative percent difference (RPD) is calculated. The percent recovery control limits for MS and MSD analyses are specified in the laboratory documents, as are the RPD control limits for MS/MSD sample sets.

One MS/MSD analysis should be performed for every analytical batch or every 20 field samples, whichever is more frequent. The frequency requirements were met for all analyses and the percent recovery and RPD values were within the proper control limits.

Laboratory Control Samples/Laboratory Control Sample Duplicates

A laboratory control sample (LCS) is a blank sample that is spiked with a known amount of analyte and then analyzed. An LCS is similar to an MS, but without the possibility of matrix interference. Given that matrix interference is not an issue, the LCS/LCSD control limits for accuracy and precision are usually more rigorous than for MS/MSD analyses. Additionally, data qualification based on LCS/LCSD analyses would apply to all samples in the associated batch, instead of just the parent sample. The percent recovery control limits for LCS and LCSD analyses are specified in the laboratory documents, as are the RPD control limits for LCS/LCSD sample sets.

One LCS/LCSD analysis should be performed for every analytical batch or every 20 field samples, whichever is more frequent. The frequency requirements were met for all analyses and the percent recovery and RPD values were within the proper control limits.

Field Duplicates (FDs)

In order to assess precision, field duplicate samples were collected and analyzed along with the reviewed sample batches. The duplicate samples were analyzed for the same parameters as the associated parent samples. Precision is determined by calculating the RPD between each pair of samples. If one or more of the sample analytes has a concentration greater than five times the reporting limit for that sample, then the absolute difference is used instead of the RPD. The RPD control limit for water samples is 20 percent.

SDG 1604-158: One field duplicate sample pair, MW-ES-07-160419 and DUP-2-160419, was submitted with this SDG. The precision criteria for all volatile target analytes were met for this sample pair.

SDG 1604-159: One field duplicate sample pair, MW-101A-160419 and DUP-1-160419, was submitted with this SDG. The precision criteria for all volatile target analytes were met for this sample pair.

SDG 1604-203: One field duplicate sample pair, MW-104B-160422 and DUP-2-160422, was submitted with this SDG. The precision criteria for all volatile target analytes were met for this sample pair.

SDG 1604-230: One field duplicate sample pair, 357-160426 and DUP-1-160426, was submitted with this SDG. The precision criteria for all volatile target analytes were met for this sample pair.

SDG 1604-256: One field duplicate sample pair, PZ-725-160428 and DUP-2-160428, was submitted with this SDG. The precision criteria for all volatile target analytes were met for this sample pair.

One FD shall be collected and analyzed for every 20 field samples, or one per sampling event (whichever is greater), to verify the precision of laboratory and/or sampling methodology. The frequency requirements were met for all analyses.

Internal Standards (Low Resolution Mass Spectrometry)

Like the surrogate, an internal standard is a compound that is chemically similar to the analytes of interest, but unlikely to be found in any environmental sample. Internal standards are used only for the mass spectrometry instrumentation and are usually added to the sample aliquot after extraction has taken place. The internal standard should be analyzed at the beginning of a 12-hour sample run and the control limits for internal standard recoveries are 50 percent to 200 percent of the calibration standard. All internal standard recoveries were within the control limits.

Initial Calibrations (ICALs)

All initial calibrations were conducted according to the laboratory methods and consisted of the appropriate number of standards. All percent relative standard deviation (%RSD) values were less than +/- 30 percent and all relative response factors (RRF) were greater than 0.05.

Continuing Calibrations (CCALs)

All continuing calibrations were conducted according to the laboratory methods and consisted of the appropriate number of standards. All percent difference (%D) values were less than +/- 25 percent and all relative response factors (RRF) were greater than 0.05.

Reporting Limits

The contract required quantitation limits (CRQL) were met by the laboratory for all target analytes throughout this sampling event, with the exception of Sample MW-ES-09-160422. The CRQL was elevated from 0.20 ug/L to 0.40 ug/L in this sample, due to required sample dilution; however, the CRQL is below the ROD Remedial Goal of 5 ug/L.

OVERALL ASSESSMENT

As was determined by this data validation, the laboratory followed the specified analytical methods. Accuracy was acceptable, as demonstrated by the surrogate, LCS/LCSD, and MS/MSD percent recovery values. Precision was acceptable, as demonstrated by the LCS/LCSD, MS/MSD, and field duplicate RPD values.

No analytical results were qualified. All data are acceptable for the intended use.

REFERENCES

United States Environmental Protection Agency (USEPA). 2009. "Guidance for Labeling Externally Validated Laboratory Analytical Data for Superfund Use," EPA-540-R-08-005. January 2009.

United States Environmental Protection Agency (USEPA). 2014. "Contract Laboratory Program National Functional Guidelines for Superfund Organic Methods Data Review," EPA-540-R-014-002. August 2014.

GeoEngineers, Inc., 2013a. "Field Sampling Plan, Semiannual Groundwater Monitoring", prepared for Washington State Department of Transportation. February 15, 2013.

GeoEngineers, Inc., 2013b. "Quality Assurance Project Plan, Subdrain System and Treatment Lagoon Sampling," prepared for Washington State Department of Transportation. February 15, 2013.

Data Validation Report

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Project: Palermo Wellfield Remedial Investigation and Feasibility Study August/September 2016 Groundwater Monitoring and Subdrain System Sampling

GEI File No: 0180-121-11

Date: September 25, 2016

This report documents the results of a United States Environmental Protection Agency (USEPA)-defined Stage 2B data validation (USEPA Document 540-R-08-005; USEPA 2009) of analytical data from the analyses of water samples collected as part of the August and September 2016 Groundwater and Subdrain System sampling events, and the associated laboratory and field quality control (QC) samples. The samples were obtained from the Palermo Wellfield Superfund Site located in Tumwater, Washington.

OBJECTIVE AND QUALITY CONTROL ELEMENTS

GeoEngineers, Inc. (GeoEngineers) completed the data validation consistent with USEPA Contract Laboratory Program National Functional Guidelines for Superfund Organic Methods Data Review (USEPA 2014) (National Functional Guidelines) to determine if the laboratory analytical results meet the project objectives and are usable for their intended purpose. Data usability was assessed by determining if:

- The samples were analyzed using well-defined and acceptable methods that provide reporting limits below applicable regulatory criteria;
- The precision and accuracy of the data are well-defined and sufficient to provide defensible data; and
- The quality assurance/quality control (QA/QC) procedures utilized by the laboratory meet acceptable industry practices and standards.

In accordance with the Field Sampling Plan, Semiannual Groundwater Monitoring (GeoEngineers 2013a) and Quality Assurance Project Plan Subdrain System and Treatment Lagoon Sampling (GeoEngineers 2013b), the data validation included review of the following QC elements:

- Data Package Completeness
- Chain-of-Custody Documentation
- Holding Times and Sample Preservation
- Surrogate Recoveries
- Method, Trip, and Rinsate Blanks
- Matrix Spikes/Matrix Spike Duplicates
- Laboratory Control Samples/Laboratory Control Sample Duplicates
- Field Duplicates (FDs)
- Internal Standards
- Initial Calibrations (ICALs)

- Continuing Calibrations (CCALs)
- Reporting Limits

VALIDATED SAMPLE DELIVERY GROUPS

This data validation included review of the sample delivery groups (SDGs) listed below in Table 1.

TABLE 1. SUMMARY OF VALIDATED SAMPLE DELIVERY GROUPS

Laboratory SDG	Samples Validated
1608-396	MW-101A-160830, MW-101B-160830, MW-109-160830, RB-1-160830, TB-1-160830
1608-397	MW-100-160830, MW-ES-07-160830, MW-UI-160830, DUP-2-160830, RB-2-160830, TB-2-160830
1609-008	MW-96-15-160831, MW-ES-05-160831, MW-ES-06-160831, RB-1-160831, TB-1-160831
1609-009	MW-4A-160831, MW-4B-160831, MW-111-160831, MW-ES-02-160831, DUP-2-160831, RB-2-160831, TB-2-160831
1609-022	MW-93-02-160901, MW-107-160901, MW-110-160901, RB-1-160901, TB-1-160901
1609-023	MW-96-17-160901, MW-102-160901, MW-103-160901, RB-2-160901, TB-2-160901
1609-049	MW-ES-11-160902, WDOT-MW-1-160902, WDOT-MW-2-160902, RB-1-160902, TB-1-160902
1609-050	MW-96-16-160902, DUP-2-160902, MW-104A-160902, MW-104B-160902, RB-2-160902, TB-2-160902
1609-060	MW-ES-09-160906, MW-ES-10-160906, ST-2-160906, TW-4-160906, TW-8-160906, RB-1-160906, TB-1-160906
1609-061	PZ-723-160906, PZ-726-160906, DUP-2-160906, PZ-728-160906, RPZ-730-160906, RPZ-731-160906, RPZ-732-160906, TB-2-160906
1609-073	PZ-719-160907, PZ-720-160907, PZ-721-160907, PZ-724-160907, PZ-725-160907, TB-2-160907
1609-095	350-160908, 356-160908, 357-160908, DUP-1-160908, 358-160908, 359-160908, 360-160908, 361-160908, 364-160908, RIN-1-160908, TB-1-160908

CHEMICAL ANALYSIS PERFORMED

OnSite Environmental, Inc. (OnSite), located in Redmond, Washington, performed laboratory analysis on the water samples using the following method:

- Volatile Organic Compounds (VOCs) by Method SW8260C

DATA VALIDATION SUMMARY

The results for each of the QC elements are summarized below.

Data Package Completeness

OnSite provided all required deliverables for the data validation according to the National Functional Guidelines. The laboratory followed adequate corrective action processes and all identified anomalies were discussed in the relevant laboratory case narrative.

Chain-of-Custody Documentation

Chain-of-custody (COC) forms were provided with the laboratory analytical reports. The COCs were accurate and complete when submitted to the laboratory.

Holding Times and Sample Preservation

The sample holding time is defined as the time that elapses between sample collection and sample analysis. Maximum holding time criteria exist for each analysis to help ensure that the analyte concentrations found at the time of analysis reflect the concentration present at the time of sample collection. Established holding times were met for all analyses. The samples within all cooler containers were properly protected with bubble wrap, preserved with wet ice and arrived at the laboratory at the appropriate temperatures of between two and six degrees Celsius, with four exceptions where the temperature was slightly below the lower limit. The out-of-compliance temperatures are detailed below.

SDGs 1609-022, 1609-049, 1609-050, and 1609-073: The sample cooler temperature recorded at the laboratory was zero degrees Celsius. It was determined through professional judgment that since the samples were not frozen, this temperature should not affect the sample analytical results.

Surrogate Recoveries

A surrogate compound is a compound that is chemically similar to the organic analytes of interest, but unlikely to be found in any environmental sample. Surrogates are used for organic analyses and are added to all samples, standards, and blanks to serve as an accuracy and specificity check of each analysis. The surrogates are added to the samples at a known concentration and percent recoveries are calculated following analysis. All surrogate percent recoveries for field samples were within the laboratory control limits.

Method, Trip, and Rinsate Blanks

Method blanks are analyzed to ensure that laboratory procedures and reagents do not introduce measurable concentrations of the analytes of interest. A method blank was analyzed with each batch of samples, at a frequency of 1 per 20 samples. For all sample batches, method blanks were analyzed at the required frequency. None of the analytes of interest were detected above the reporting limits in any of the method blanks.

Trip blanks are analyzed to provide an indication as to whether volatile compounds have cross-contaminated other like samples within the transportation process to the laboratory. Twelve (12) trip blanks were collected (one for each cooler): TB-1-160830, TB-2-160830, TB-1-160831, TB-2-160831, TB-1-160901, TB-2-160901, TB-1-160902, TB-2-160902, TB-1-160906, TB-2-160906, TB-2-160907, and TB-1-160908. None of the analytes of interest were detected above the reporting limits in any of the trip blanks.

Equipment rinsate blanks are analyzed to provide an indication as to whether field decontamination and sampling procedures effectively prevent cross-contamination in field activities. Ten (10) equipment rinsate blanks were collected: RB-1-160830, RB-2-160830, RB-1-160831, RB-2-160831, RB-1-160901, RB-2-160901, RB-1-160902, RB-2-160902, RB-1-160906, and RIN-1-160908. None of the analytes of interest were detected above the reporting limits in any of the rinsate blanks.

Matrix Spikes/Matrix Spike Duplicates

Since the actual analyte concentration in an environmental sample is not known, the accuracy of a particular analysis is usually inferred by performing a matrix spike (MS) analysis on one sample from the associated batch, known as the parent sample. One aliquot of the sample is analyzed in the normal manner and then a second aliquot of the sample is spiked with a known amount of analyte concentration and analyzed. From these analyses, a percent recovery is calculated. Matrix spike duplicate (MSD) analyses are generally performed for organic analyses as a precision check and analyzed in the same sequence as a matrix spike. Using the result values from the MS and MSD, the relative percent difference (RPD) is calculated. The percent recovery control limits for MS and MSD analyses are specified in the laboratory documents, as are the RPD control limits for MS/MSD sample sets.

One MS/MSD analysis should be performed for every analytical batch or every 20 field samples, whichever is more frequent. The frequency requirements were met for all analyses and the percent recovery and RPD values were within the proper control limits.

Laboratory Control Samples/Laboratory Control Sample Duplicates

A laboratory control sample (LCS) is a blank sample that is spiked with a known amount of analyte and then analyzed. An LCS is similar to an MS, but without the possibility of matrix interference. Given that matrix interference is not an issue, the LCS/LCSD control limits for accuracy and precision are usually more rigorous than for MS/MSD analyses. Additionally, data qualification based on LCS/LCSD analyses would apply to all samples in the associated batch, instead of just the parent sample. The percent recovery control limits for LCS and LCSD analyses are specified in the laboratory documents, as are the RPD control limits for LCS/LCSD sample sets.

One LCS/LCSD analysis should be performed for every analytical batch or every 20 field samples, whichever is more frequent. The frequency requirements were met for all analyses and the percent recovery and RPD values were within the proper control limits.

Field Duplicates (FDs)

In order to assess precision, field duplicate samples were collected and analyzed along with the reviewed sample batches. The duplicate samples were analyzed for the same parameters as the associated parent samples. Precision is determined by calculating the RPD between each pair of samples. If one or more of the sample analytes has a concentration greater than five times the reporting limit for that sample, then the absolute difference is used instead of the RPD. The RPD control limit for water samples is 20 percent.

SDG 1608-397: One field duplicate sample pair, MW-UI-160830 and DUP-2-160830, was submitted with this SDG. The precision criteria for all volatile target analytes were met for this sample pair.

SDG 1609-009: One field duplicate sample pair, MW-ES-02-160831 and DUP-2-160831, was submitted with this SDG. The precision criteria for all volatile target analytes were met for this sample pair.

SDG 1609-050: One field duplicate sample pair, MW-96-16-160902 and DUP-2-160902, was submitted with this SDG. The precision criteria for all volatile target analytes were met for this sample pair.

SDG 1609-061: One field duplicate sample pair, PZ-726-160906 and DUP-2-160906, was submitted with this SDG. The precision criteria for all volatile target analytes were met for this sample pair.

SDG 1609-095: One field duplicate sample pair, 357-160908 and DUP-1-160908, was submitted with this SDG. The precision criteria for all volatile target analytes were met for this sample pair.

One FD shall be collected and analyzed for every 20 field samples, or one per sampling event (whichever is greater), to verify the precision of laboratory and/or sampling methodology. The frequency requirements were met for all analyses.

Internal Standards (Low Resolution Mass Spectrometry)

Like the surrogate, an internal standard is a compound that is chemically similar to the analytes of interest, but unlikely to be found in any environmental sample. Internal standards are used only for the mass spectrometry instrumentation and are usually added to the sample aliquot after extraction has taken place. The internal standard should be analyzed at the beginning of a 12-hour sample run and the control limits for internal standard recoveries are 50 percent to 200 percent of the calibration standard. All internal standard recoveries were within the control limits.

Initial Calibrations (ICALs)

All initial calibrations were conducted according to the laboratory methods and consisted of the appropriate number of standards. All percent relative standard deviation (%RSD) values were less than +/- 30 percent and all relative response factors (RRF) were greater than 0.05.

Continuing Calibrations (CCALs)

All continuing calibrations were conducted according to the laboratory methods and consisted of the appropriate number of standards. All percent difference (%D) values were less than +/- 25 percent and all relative response factors (RRF) were greater than 0.05.

Reporting Limits

The contract required quantitation limits (CRQL) were met by the laboratory for all target analytes throughout this sampling event, with the exception of Sample MW-ES-09-160422. The CRQL was elevated from 0.20 ug/L to 0.40 ug/L in this sample, due to required sample dilution; however, the CRQL is below the ROD Remedial Goal of 5 ug/L.

OVERALL ASSESSMENT

As was determined by this data validation, the laboratory followed the specified analytical methods. Accuracy was acceptable, as demonstrated by the surrogate, LCS/LCSD, and MS/MSD percent recovery values. Precision was acceptable, as demonstrated by the LCS/LCSD, MS/MSD, and field duplicate RPD values.

No analytical results were qualified. All data are acceptable for the intended use.

REFERENCES

U.S. Environmental Protection Agency (USEPA). 2009. "Guidance for Labeling Externally Validated Laboratory Analytical Data for Superfund Use," EPA-540-R-08-005. January 2009.

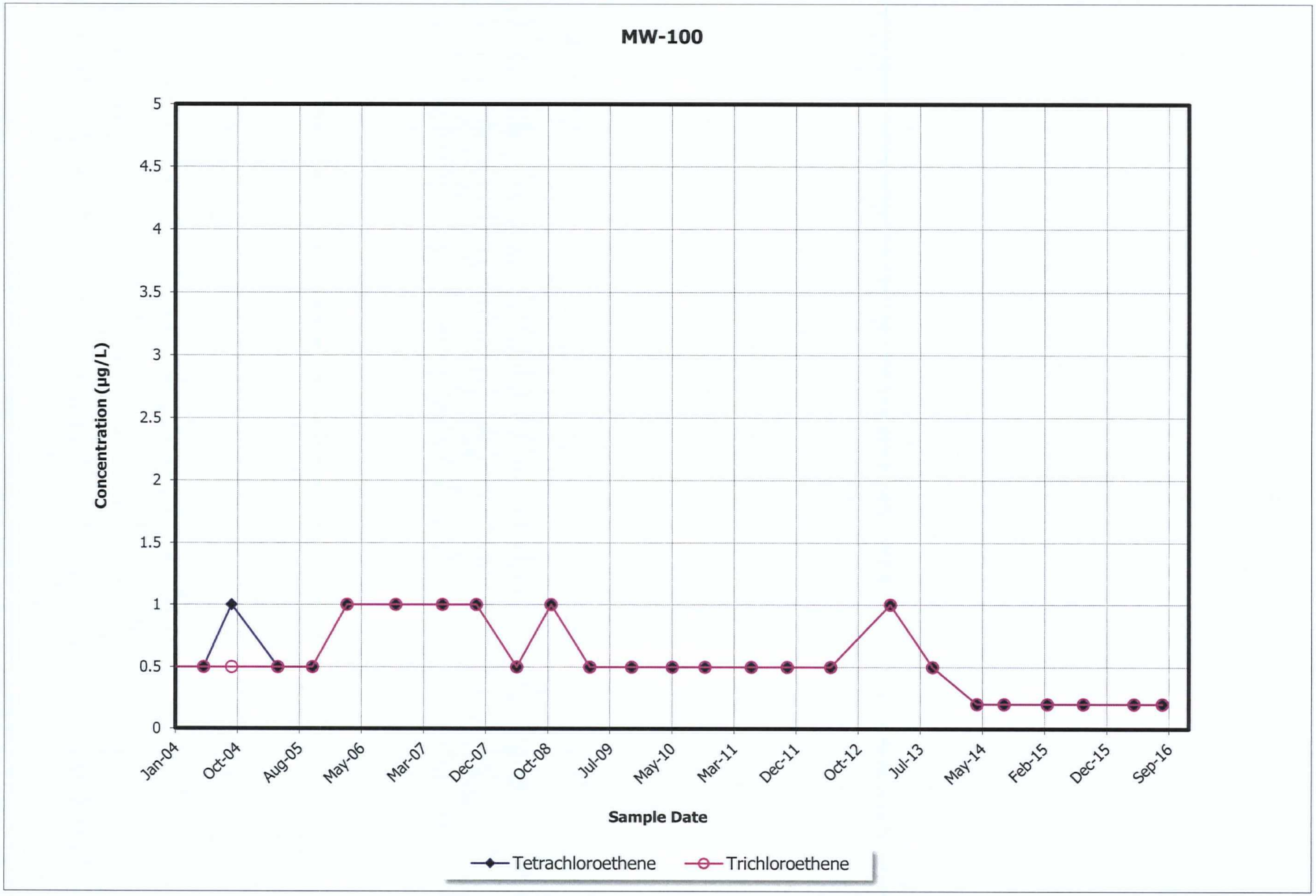
U.S. Environmental Protection Agency (USEPA). 2014. "Contract Laboratory Program National Functional Guidelines for Superfund Organic Methods Data Review," EPA-540-R-014-002. August 2014.

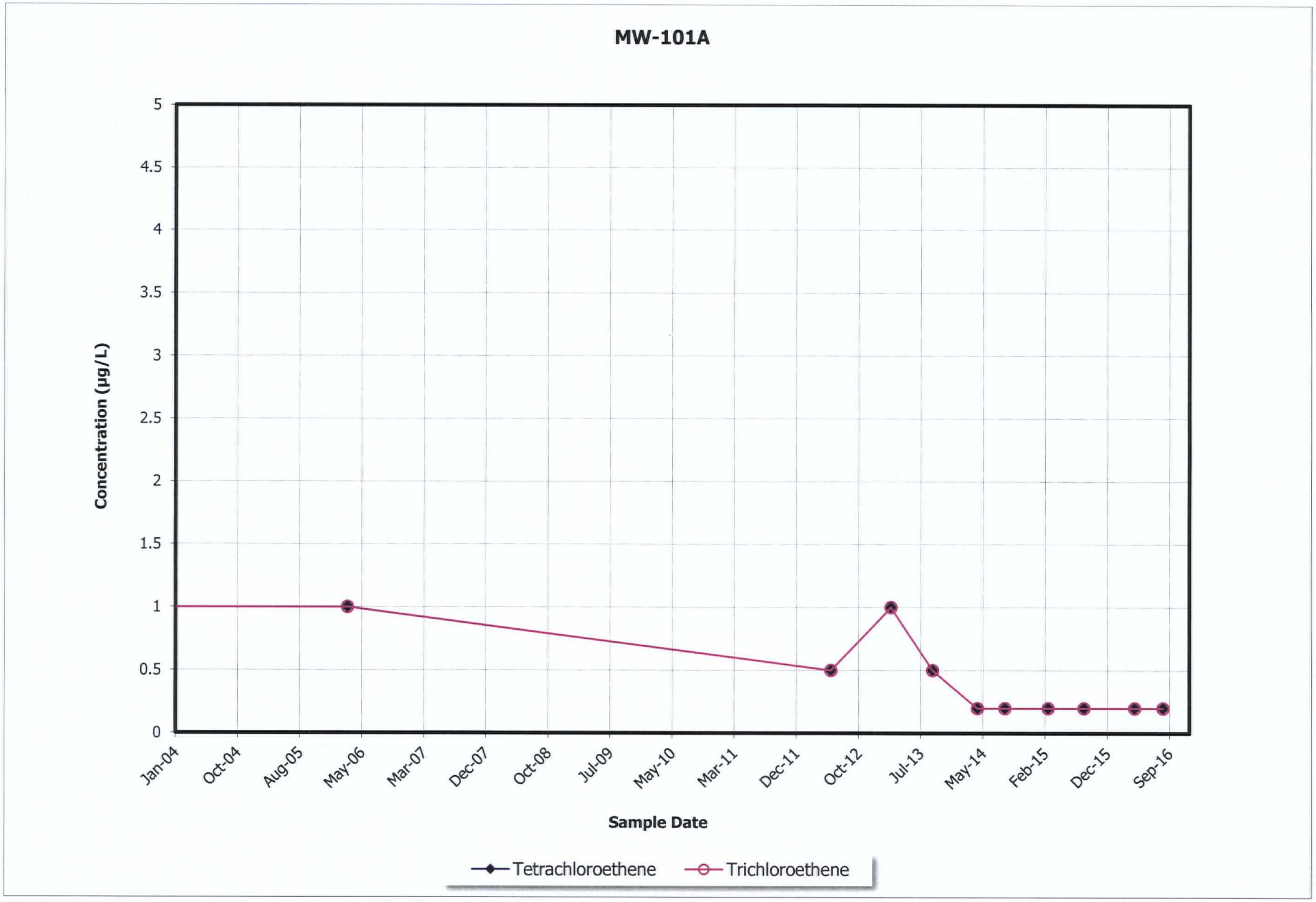
GeoEngineers, Inc., 2013a. "Field Sampling Plan, Semiannual Groundwater Monitoring", prepared for Washington State Department of Transportation. February 15, 2013.

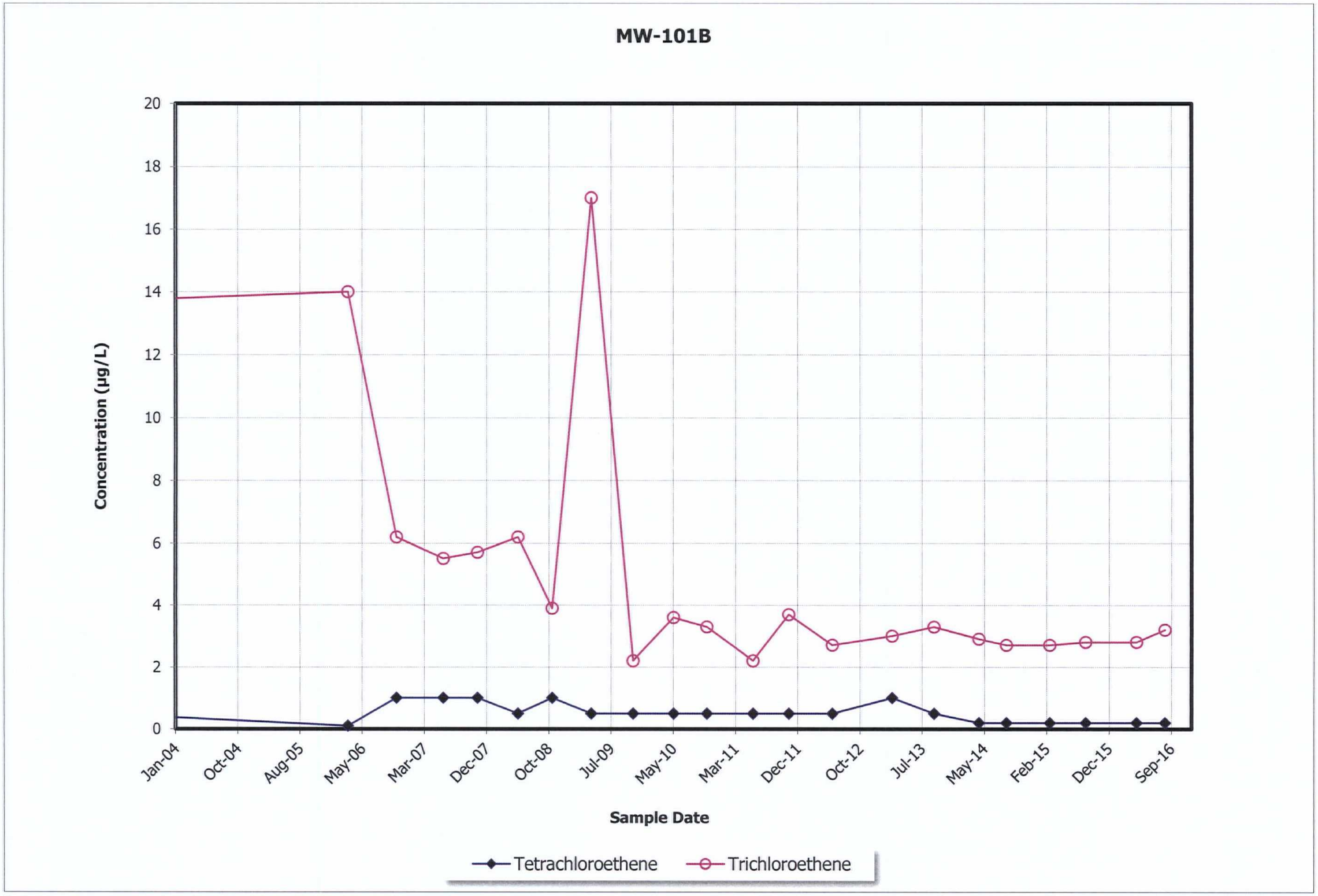
GeoEngineers, Inc., 2013b. "Quality Assurance Project Plan, Subdrain System and Treatment Lagoon Sampling," prepared for Washington State Department of Transportation. February 15, 2013.

APPENDIX D
Laboratory Analytical Data Reports
(Included on CD)

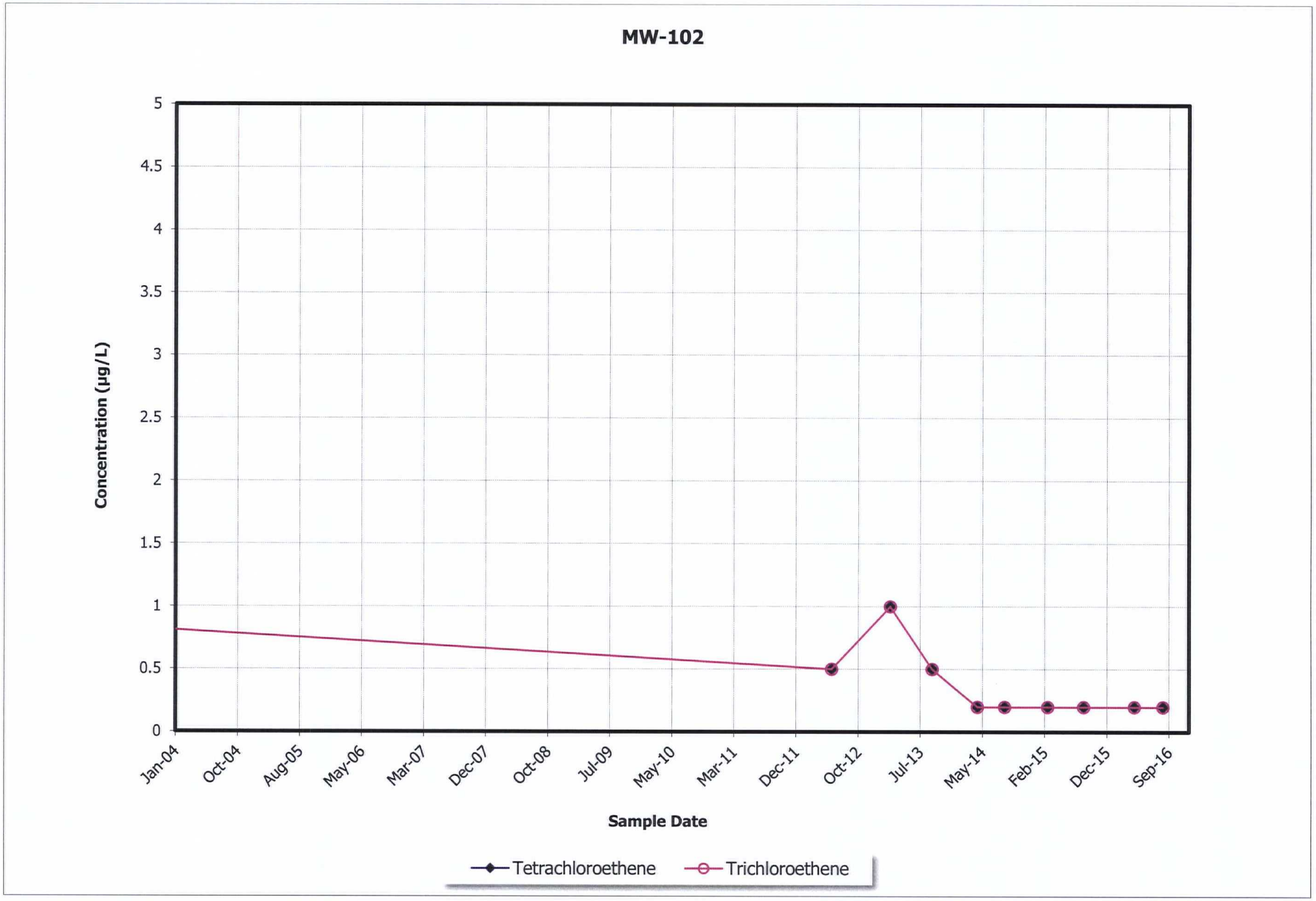
APPENDIX E
Trend Plots

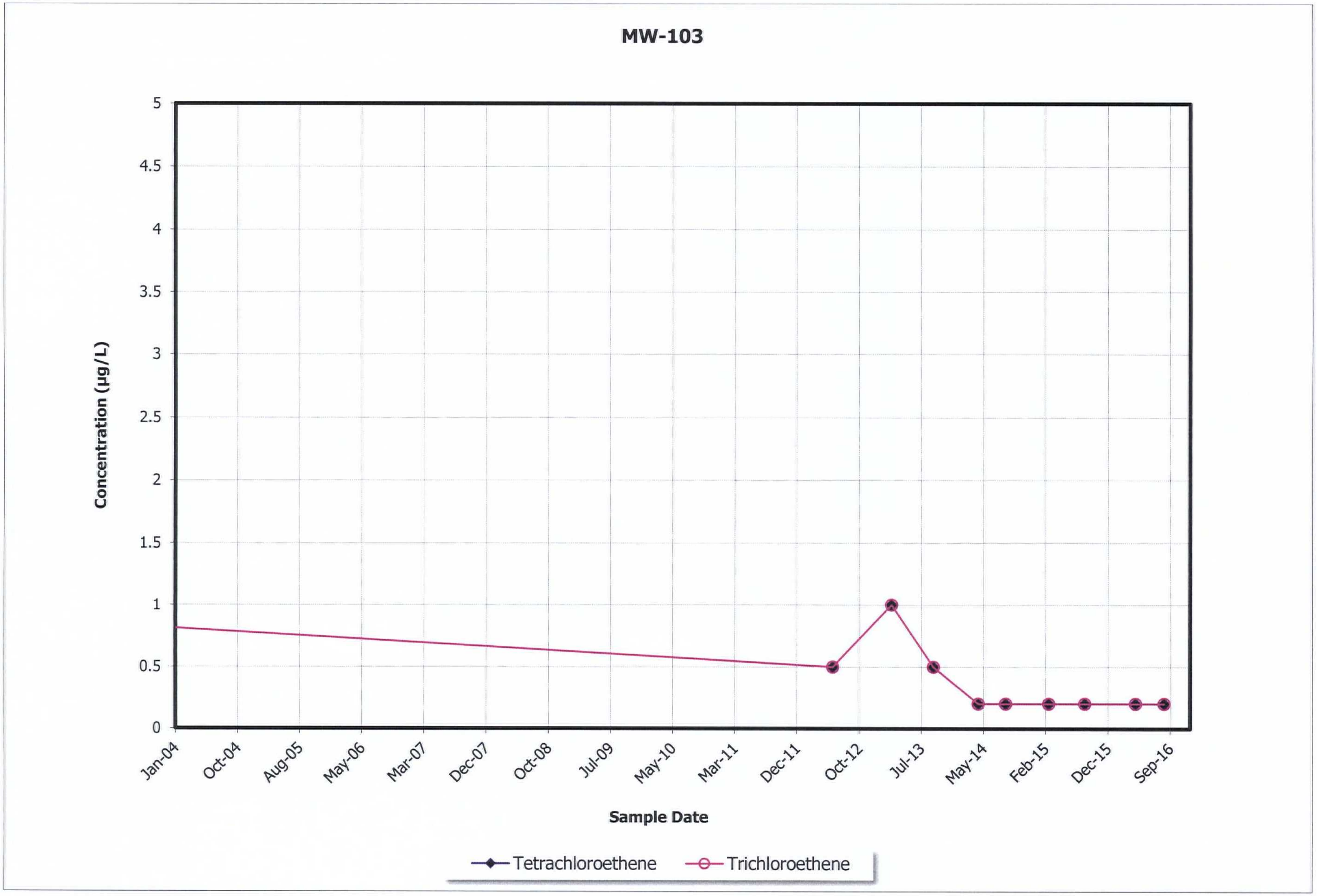

MW-100
Concentration (µg/L)
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
Jan-04
Oct-04
Aug-05
May-06
Mar-07
Dec-07
Oct-08
Jul-09
May-10
Mar-11
Dec-11
Oct-12
Jul-13
May-14
Feb-15
Dec-15
Sep-16
Sample Date
Tetrachloroethene
Trichloroethene


MW-101A
Concentration (µg/L)
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
Jan-04
Oct-04
Aug-05
May-06
Mar-07
Dec-07
Oct-08
Jul-09
May-10
Mar-11
Dec-11
Oct-12
Jul-13
May-14
Feb-15
Dec-15
Sep-16
Sample Date
Tetrachloroethene
Trichloroethene



MW-101B
Concentration (µg/L)
20
18
16
14
12
10
8
6
4
2
0
Jan-04
Oct-04
Aug-05
May-06
Mar-07
Dec-07
Oct-08
Jul-09
May-10
Mar-11
Dec-11
Oct-12
Jul-13
May-14
Feb-15
Dec-15
Sep-16
Sample Date
Tetrachloroethene
Trichloroethene


MW-102
Concentration (µg/L)
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
Jan-04
Oct-04
Aug-05
May-06
Mar-07
Dec-07
Oct-08
Jul-09
May-10
Mar-11
Dec-11
Oct-12
Jul-13
May-14
Feb-15
Dec-15
Sep-16
Sample Date
Tetrachloroethene
Trichloroethene


MW-103
Concentration (µg/L)
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
Jan-04
Oct-04
Aug-05
May-06
Mar-07
Dec-07
Oct-08
Jul-09
May-10
Mar-11
Dec-11
Oct-12
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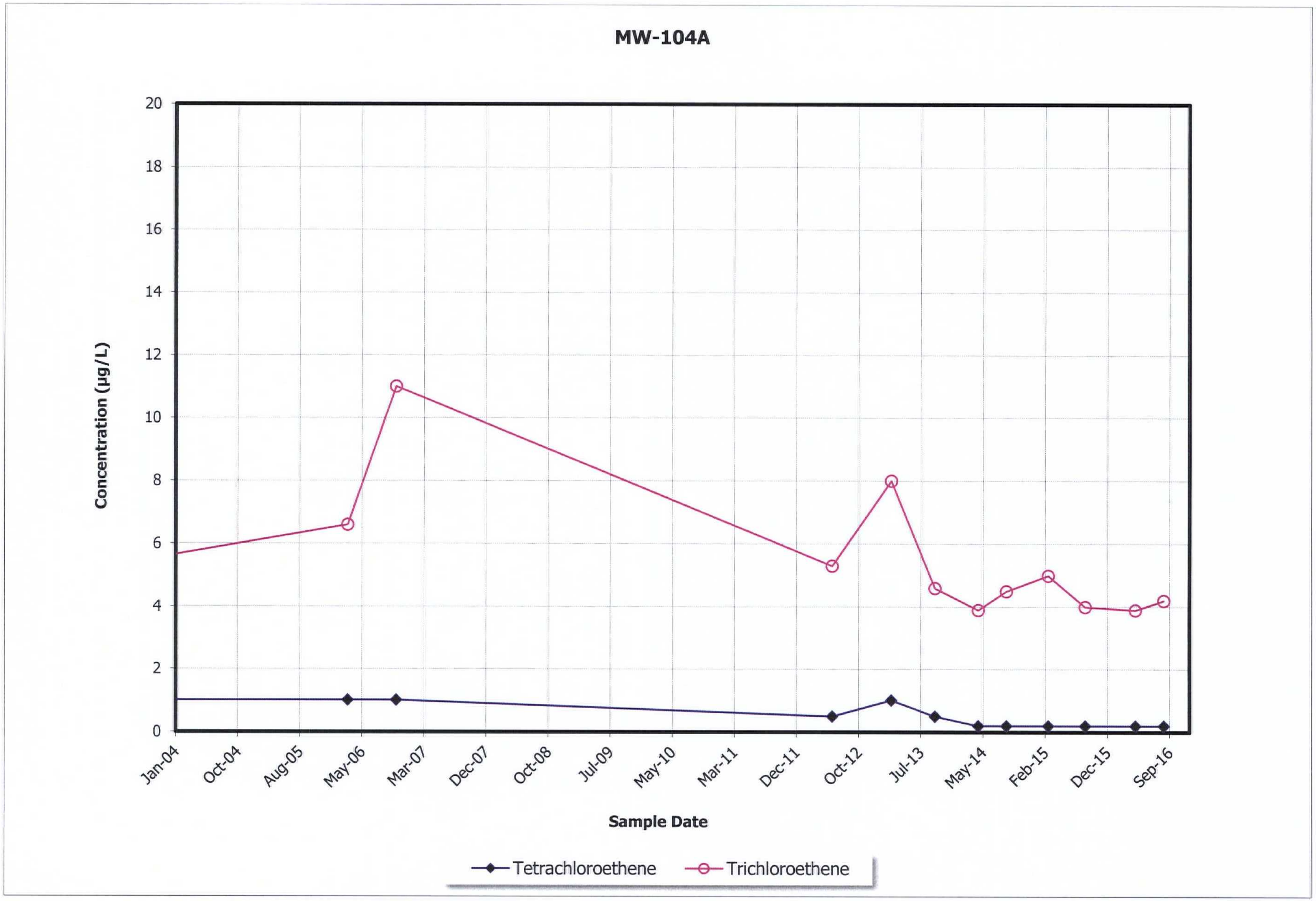
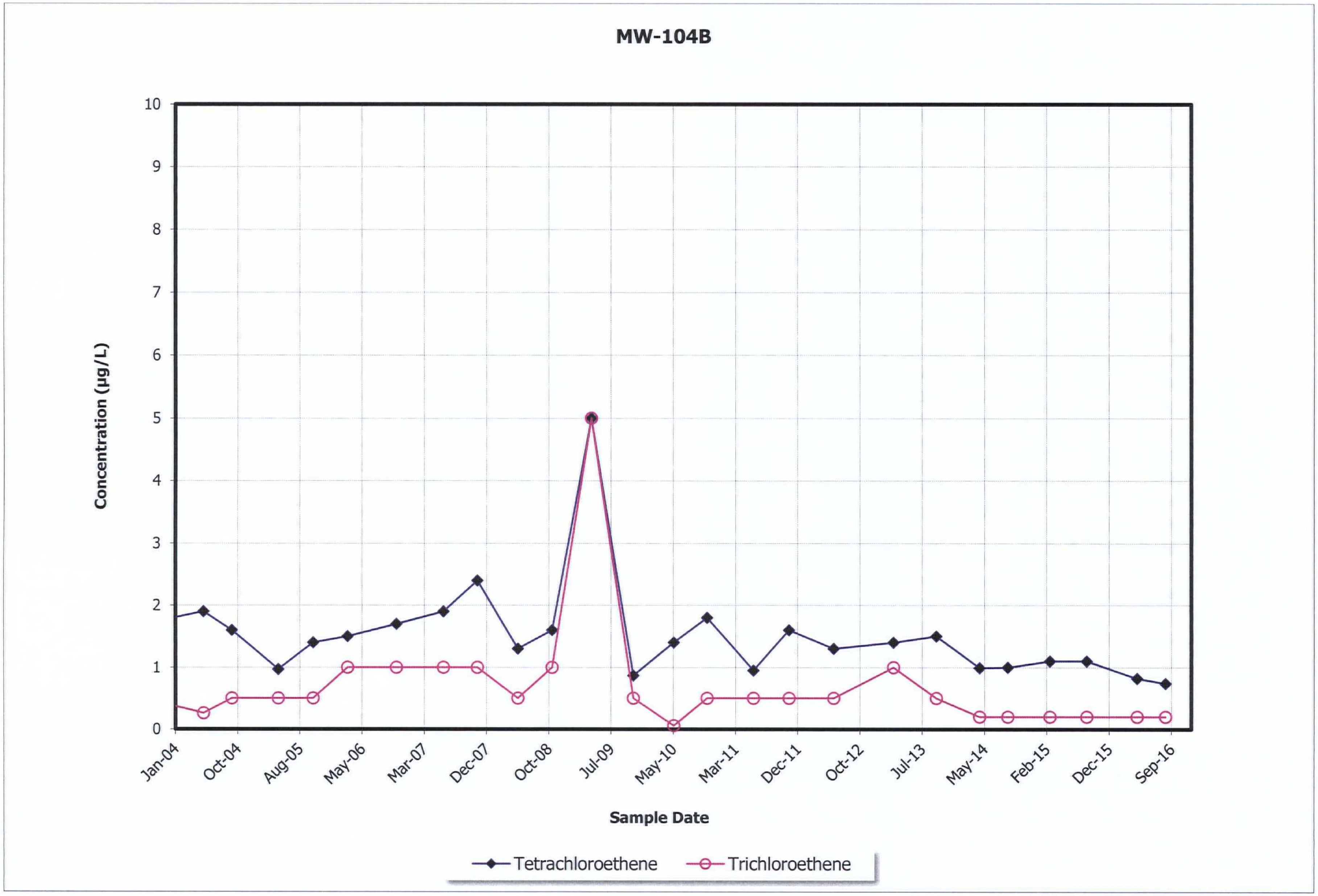
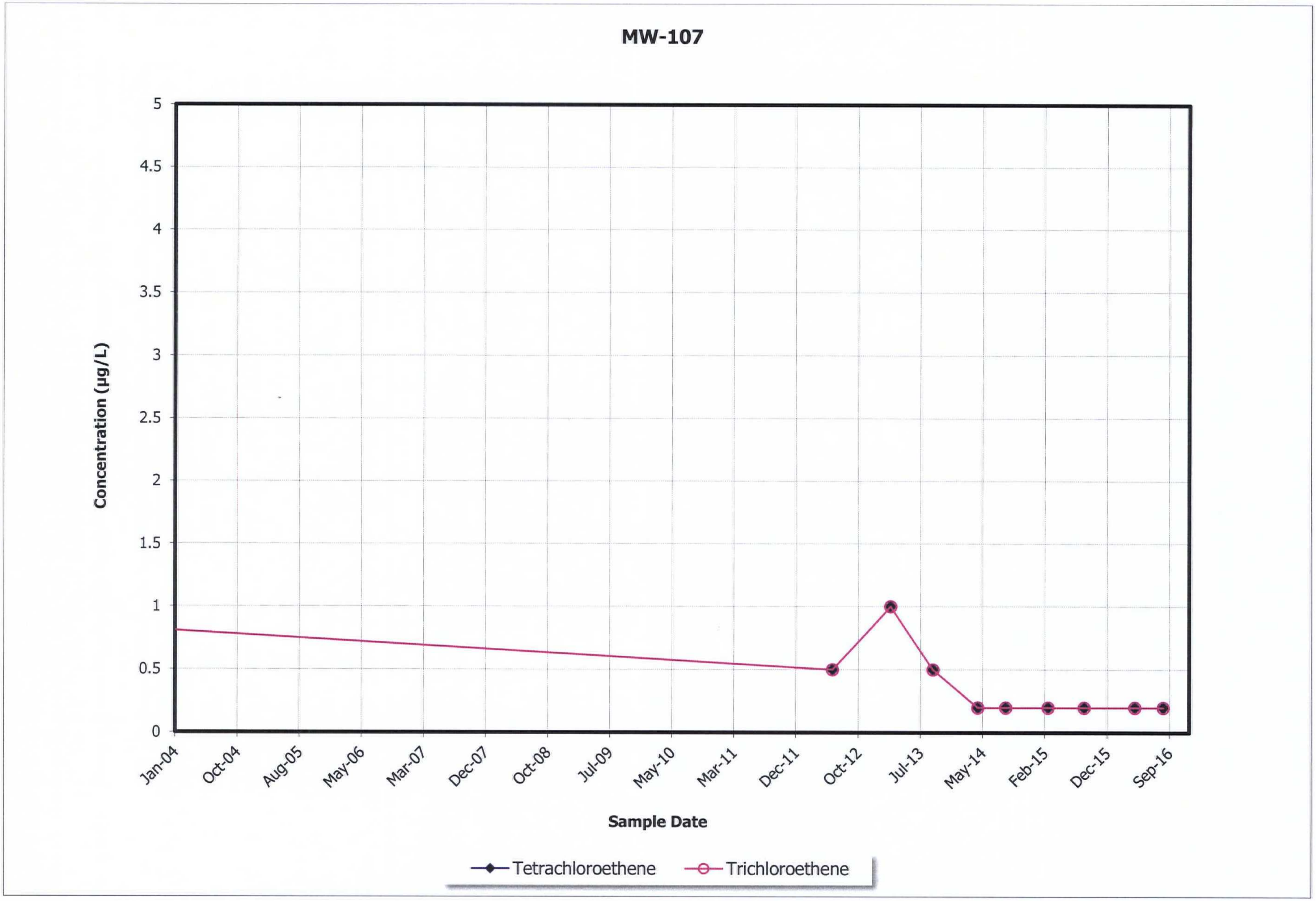
Sep-16
Sample Date
Tetrachloroethene
Trichloroethene


MW-104A
20
18
16
14
12
10
8
6
4
2
0
Concentration (µg/L)
Jan-04
Oct-04
Aug-05
May-06
Mar-07
Dec-07
Oct-08
Jul-09
May-10
Mar-11
Dec-11
Oct-12
Jul-13
May-14
Feb-15
Dec-15
Sep-16
Sample Date
Tetrachloroethene
Trichloroethene


MW-104B
Concentration (µg/L)
0
1
2
3
4
5
6
7
8
9
10
Jan-04
Oct-04
Aug-05
May-06
Mar-07
Dec-07
Oct-08
Jul-09
May-10
Mar-11
Dec-11
Oct-12
Jul-13
May-14
Feb-15
Dec-15
Sep-16
Sample Date
Tetrachloroethene
Trichloroethene


MW-107
Concentration (µg/L)
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
Jan-04
Oct-04
Aug-05
May-06
Mar-07
Dec-07
Oct-08
Jul-09
May-10
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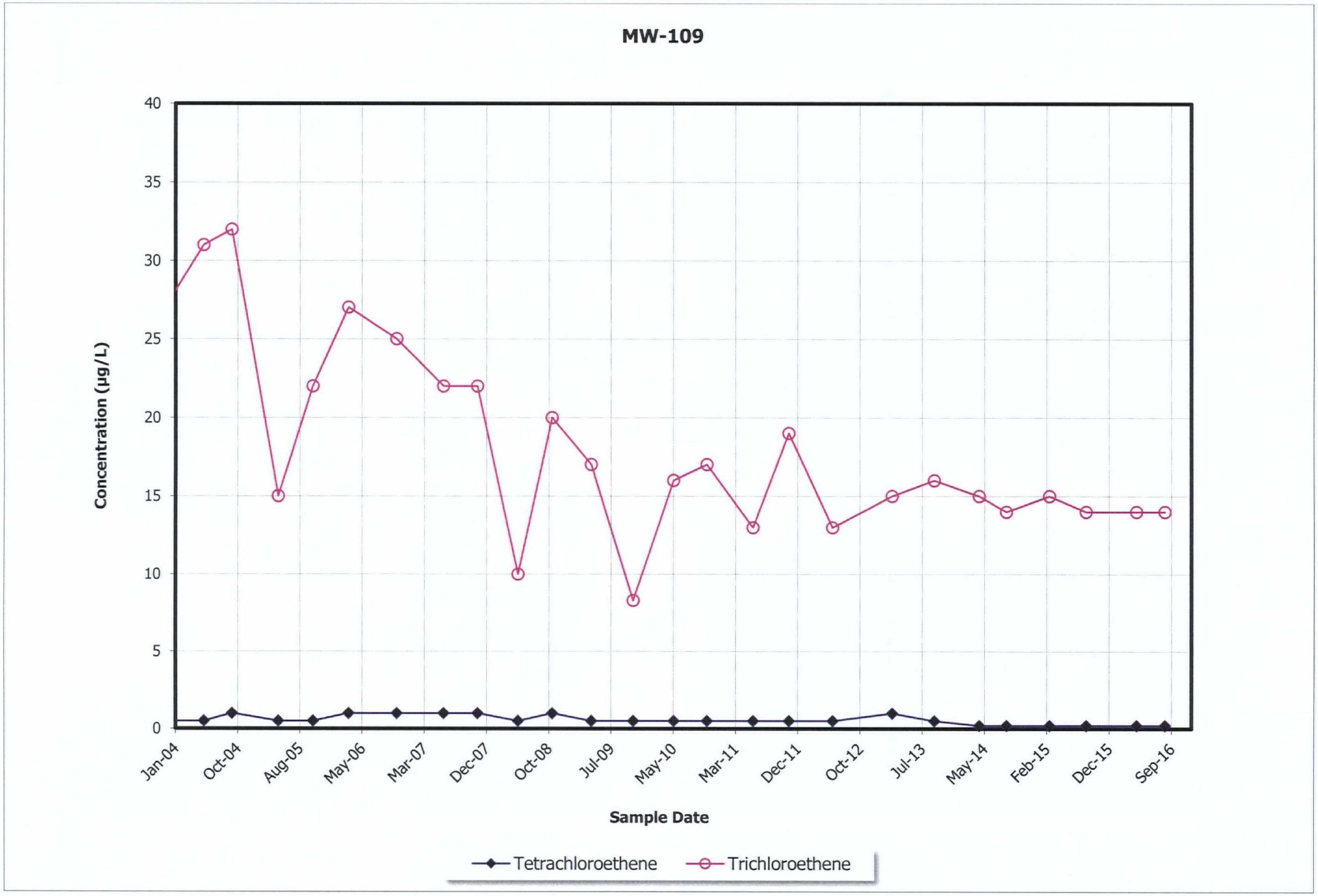
Sample Date
Tetrachloroethene
Trichloroethene



MW-109
Concentration (µg/L)
40
35
30
25
20
15
10
5
0
Jan-04
Oct-04
Aug-05
May-06
Mar-07
Dec-07
Oct-08
Jul-09
May-10
Mar-11
Dec-11
Oct-12
Jul-13
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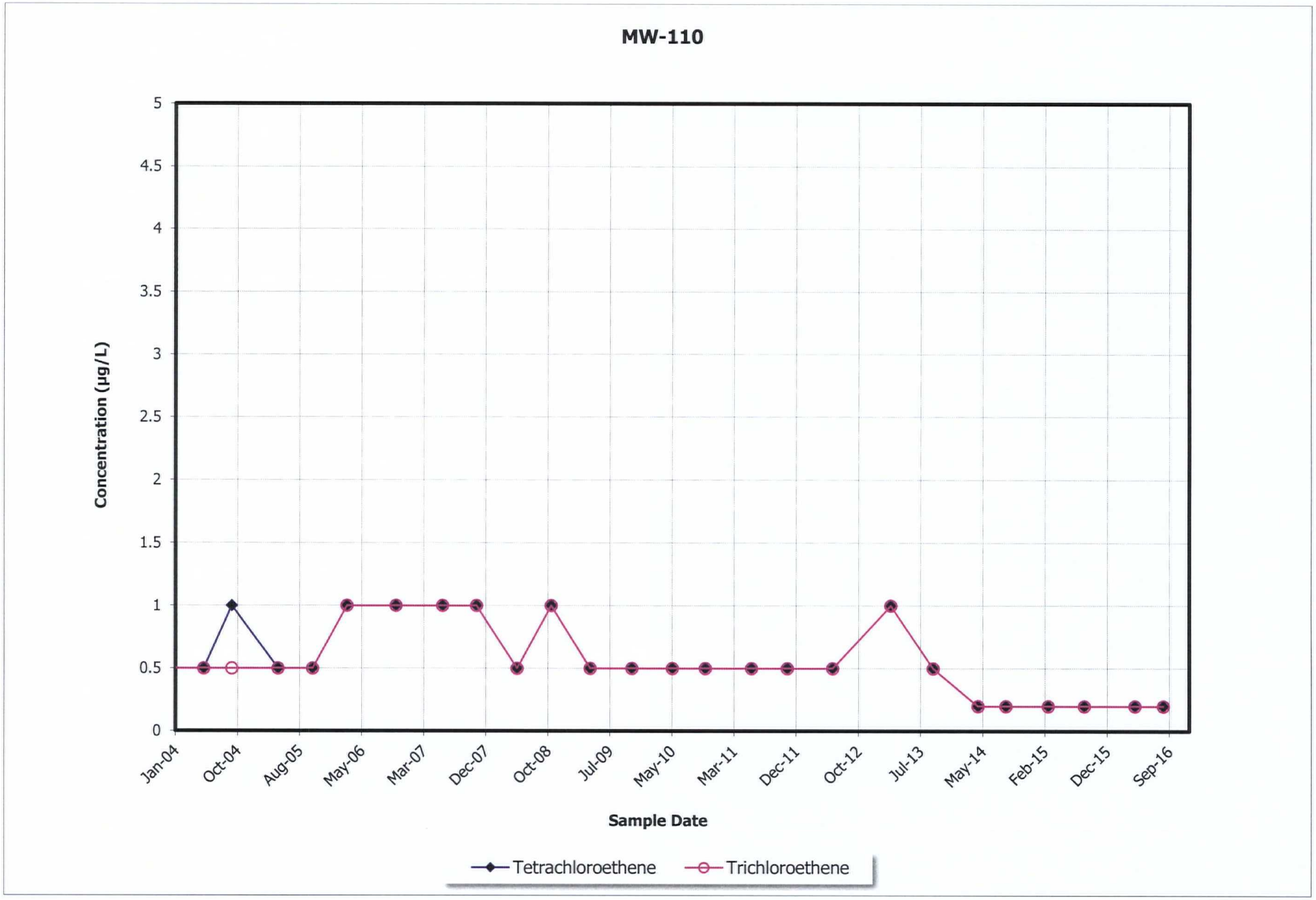
Sample Date
Tetrachloroethene
Trichloroethene



MW-110
Concentration (µg/L)
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
Jan-04
Oct-04
Aug-05
May-06
Mar-07
Dec-07
Oct-08
Jul-09
May-10
Mar-11
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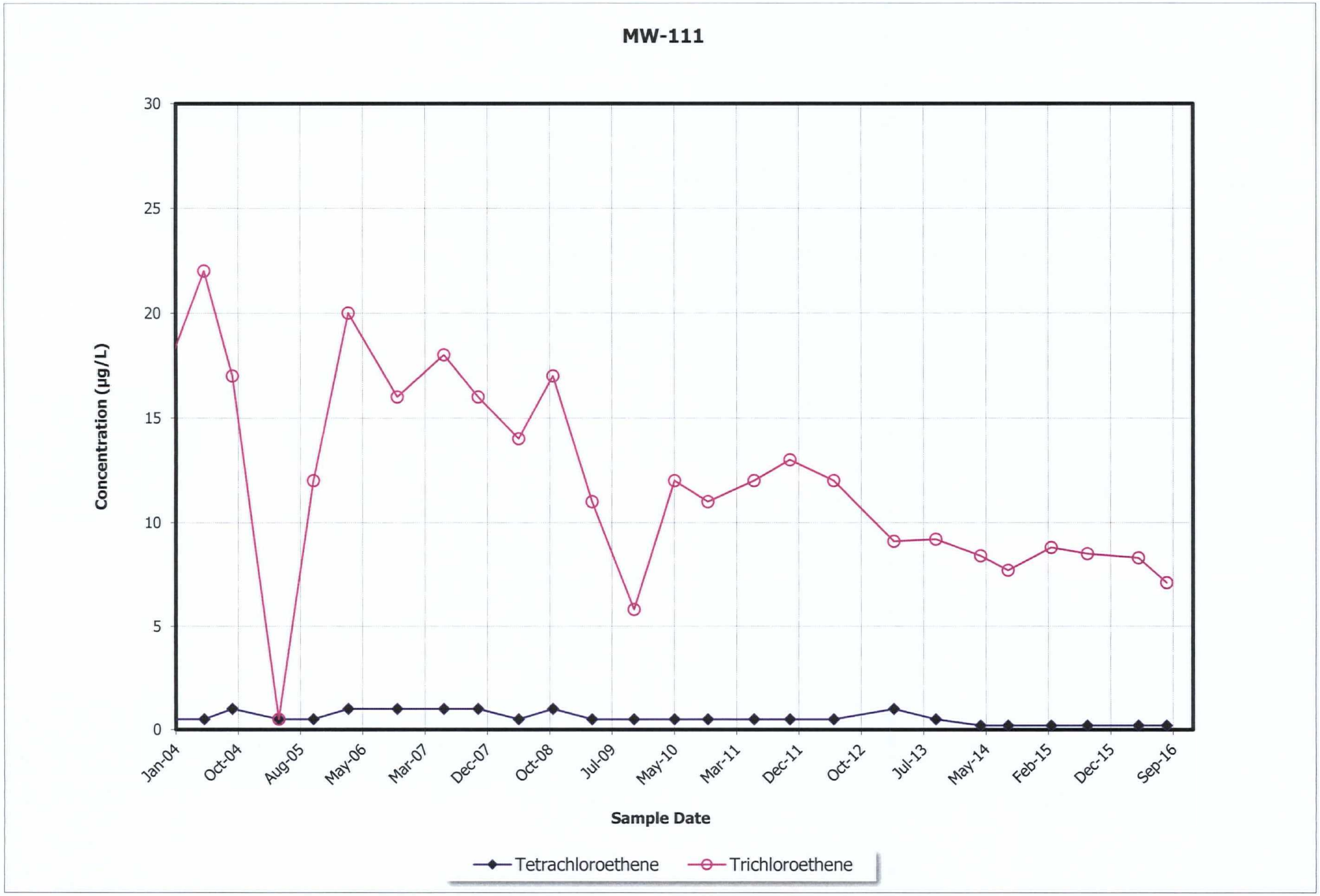
Sample Date
Tetrachloroethene
Trichloroethene



MW-111
30
25
20
15
10
5
0
Concentration (µg/L)
Jan-04
Oct-04
Aug-05
May-06
Mar-07
Dec-07
Oct-08
Jul-09
May-10
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Jul-13
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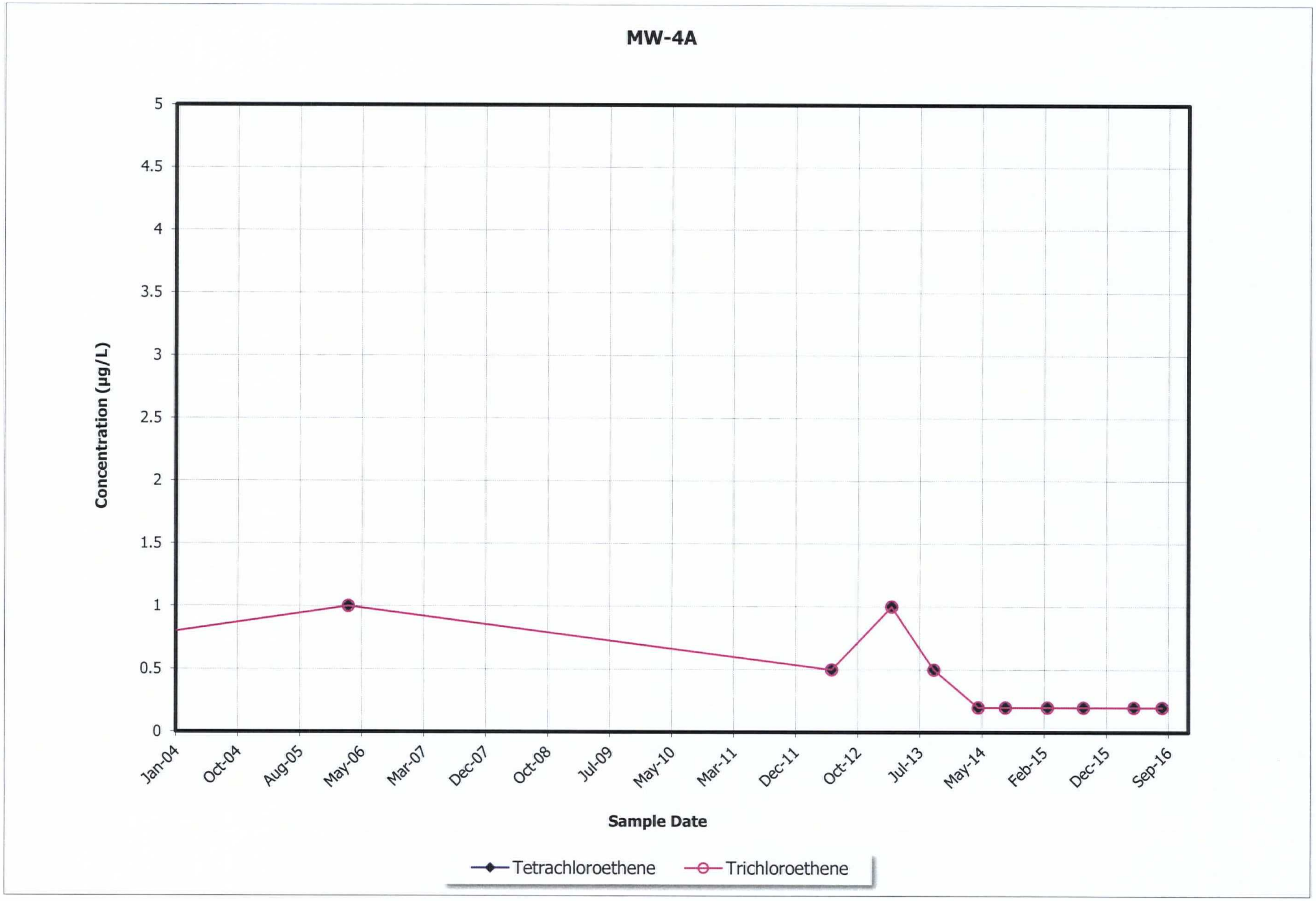
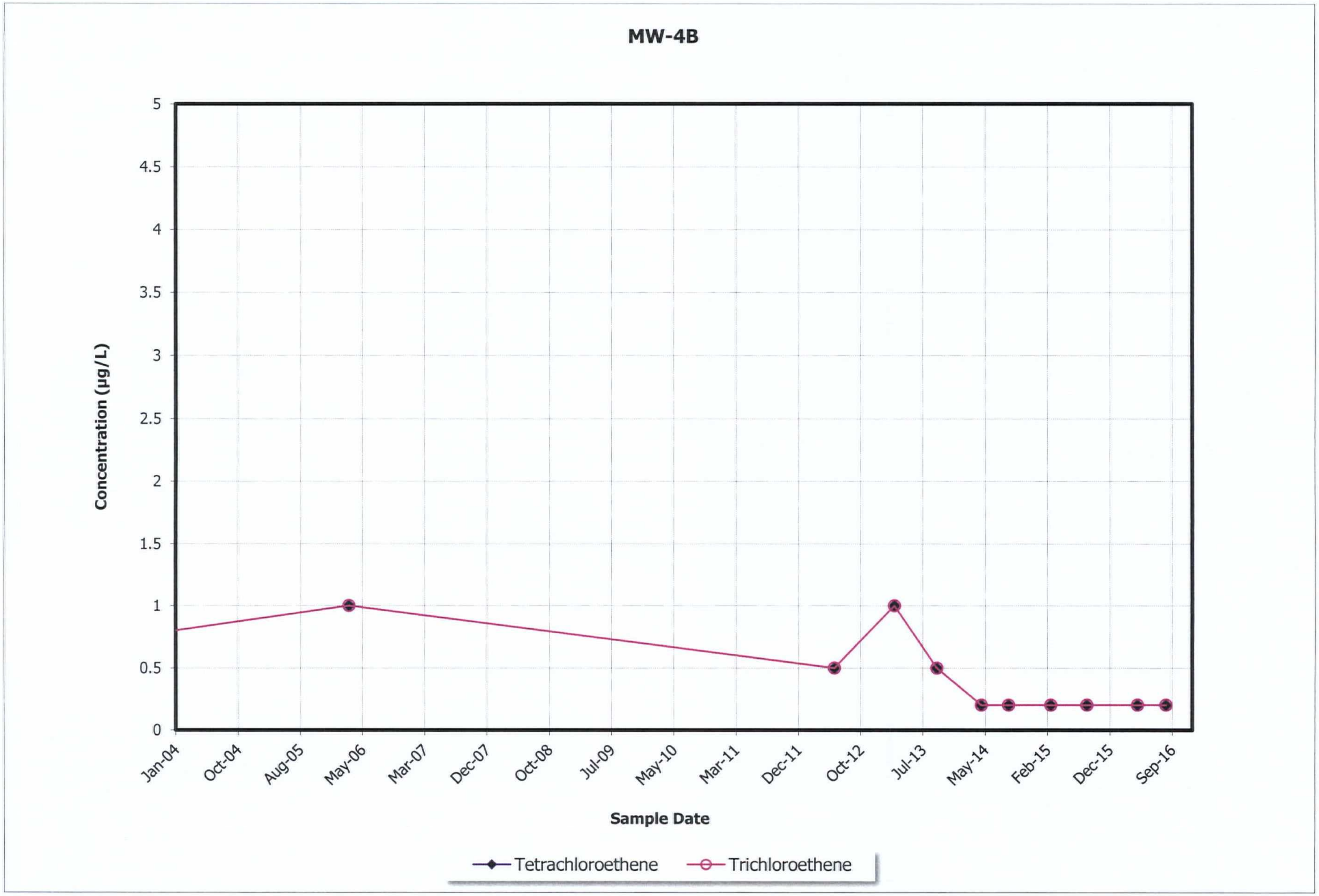
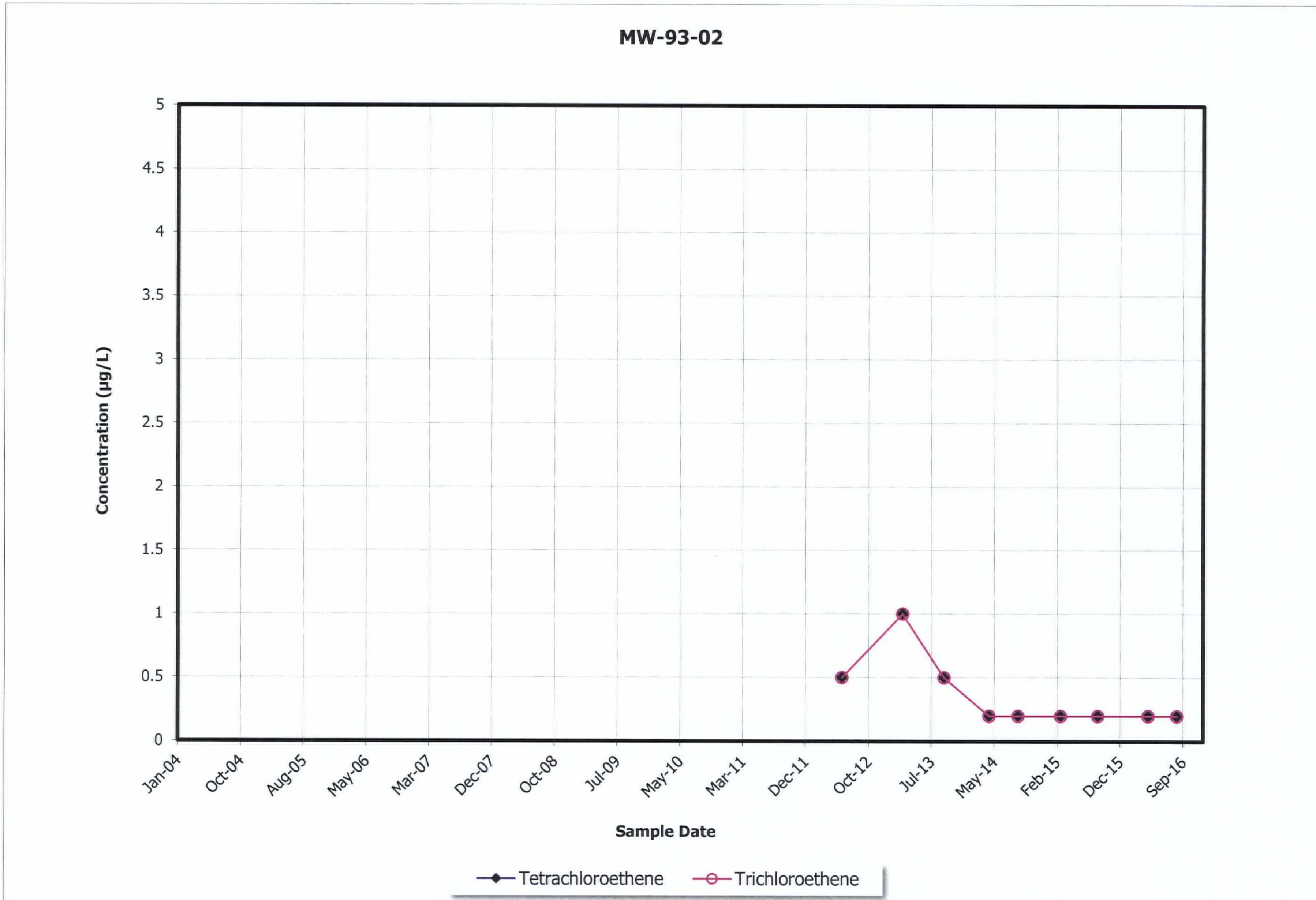
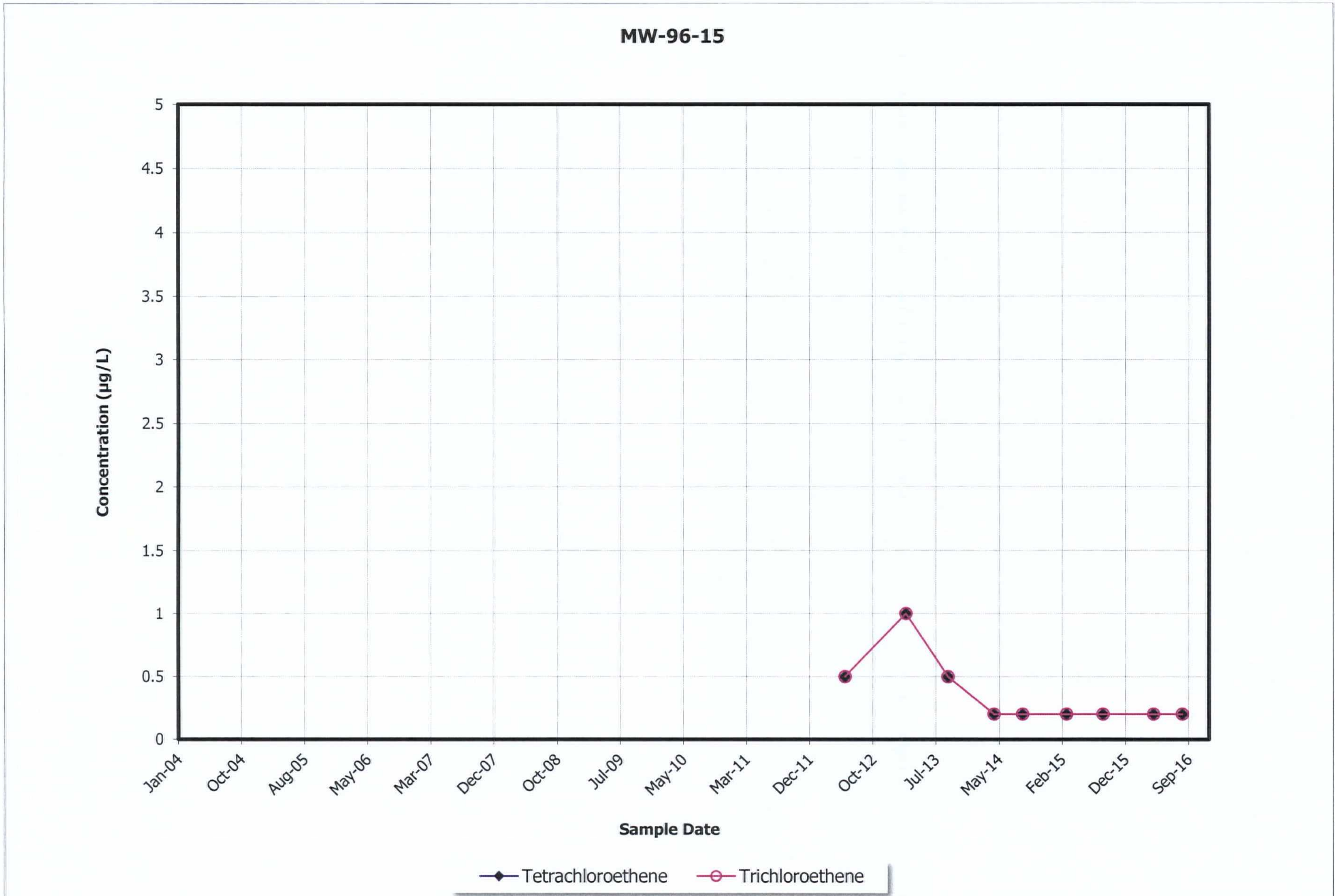
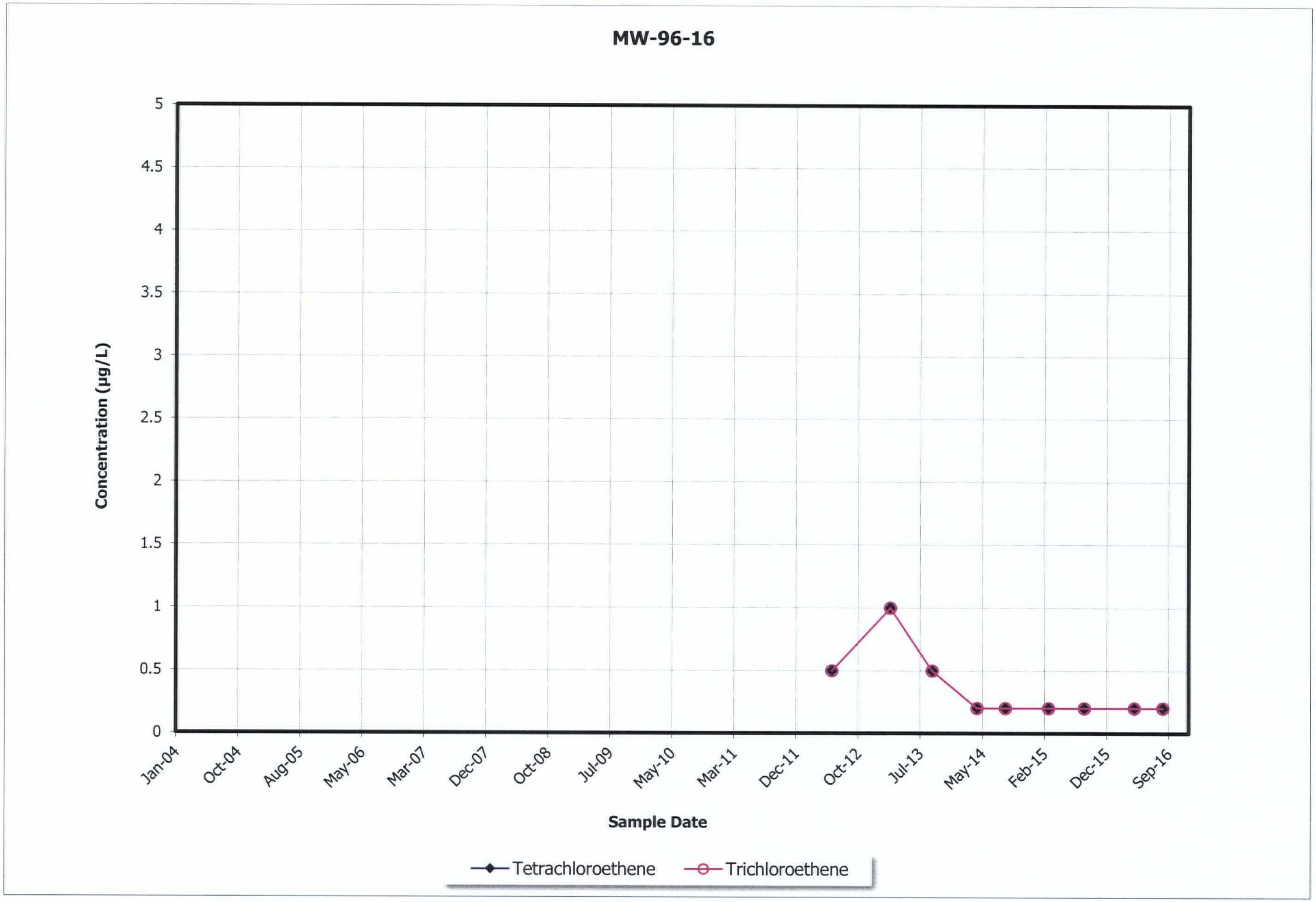
Sample Date
Tetrachloroethene
Trichloroethene

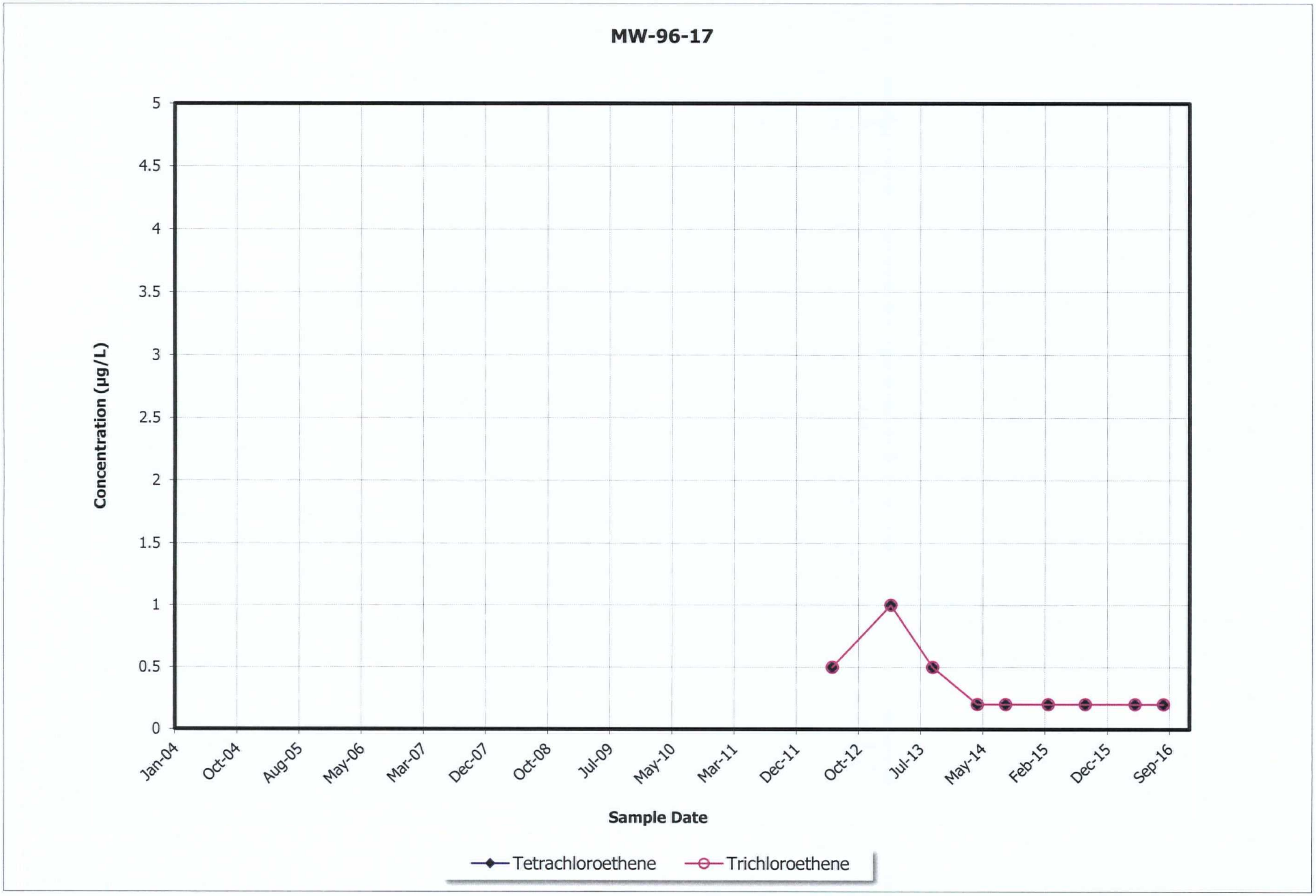

MW-4A
Concentration (µg/L)
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
Jan-04
Oct-04
Aug-05
May-06
Mar-07
Dec-07
Oct-08
Jul-09
May-10
Mar-11
Dec-11
Oct-12
Jul-13
May-14
Feb-15
Dec-15
Sep-16
Sample Date
Tetrachloroethene
Trichloroethene

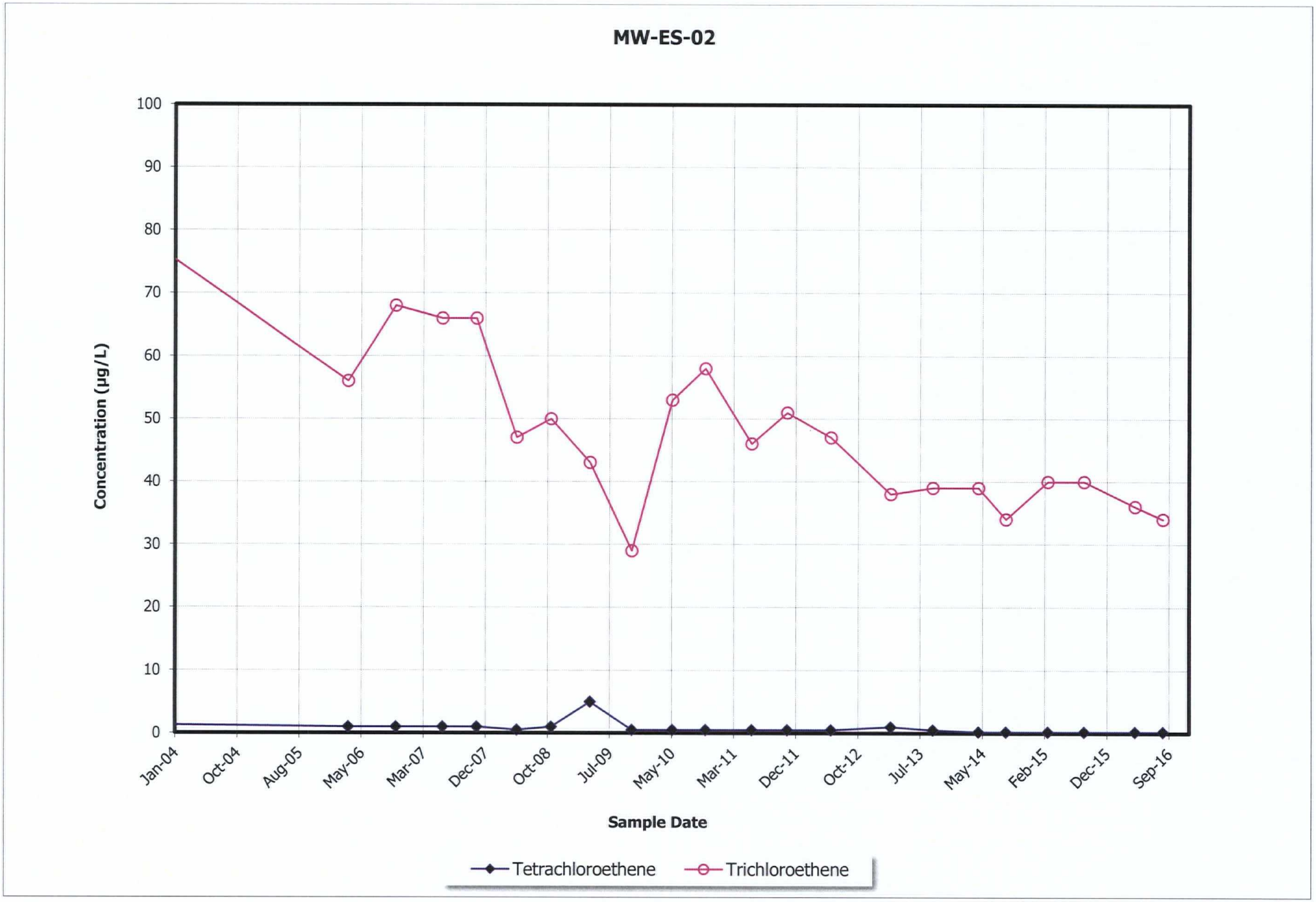

MW-4B
Concentration (µg/L)
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
Jan-04
Oct-04
Aug-05
May-06
Mar-07
Dec-07
Oct-08
Jul-09
May-10
Mar-11
Dec-11
Oct-12
Jul-13
May-14
Feb-15
Dec-15
Sep-16
Sample Date
Tetrachloroethene
Trichloroethene

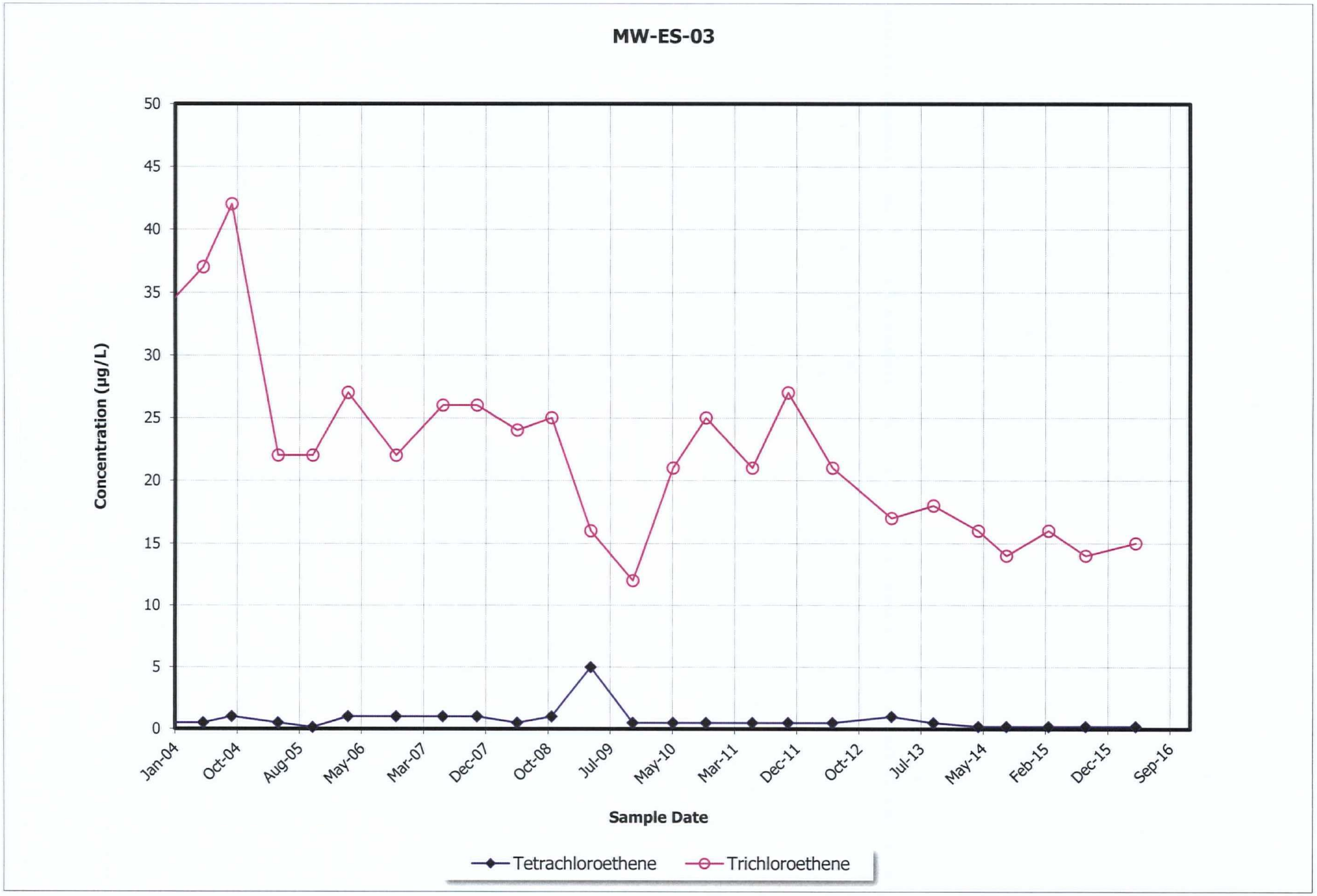

MW-93-02
Concentration (µg/L)
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
Jan-04
Oct-04
Aug-05
May-06
Mar-07
Dec-07
Oct-08
Jul-09
May-10
Mar-11
Dec-11
Oct-12
Jul-13
May-14
Feb-15
Dec-15
Sep-16
Sample Date
Tetrachloroethene
Trichloroethene

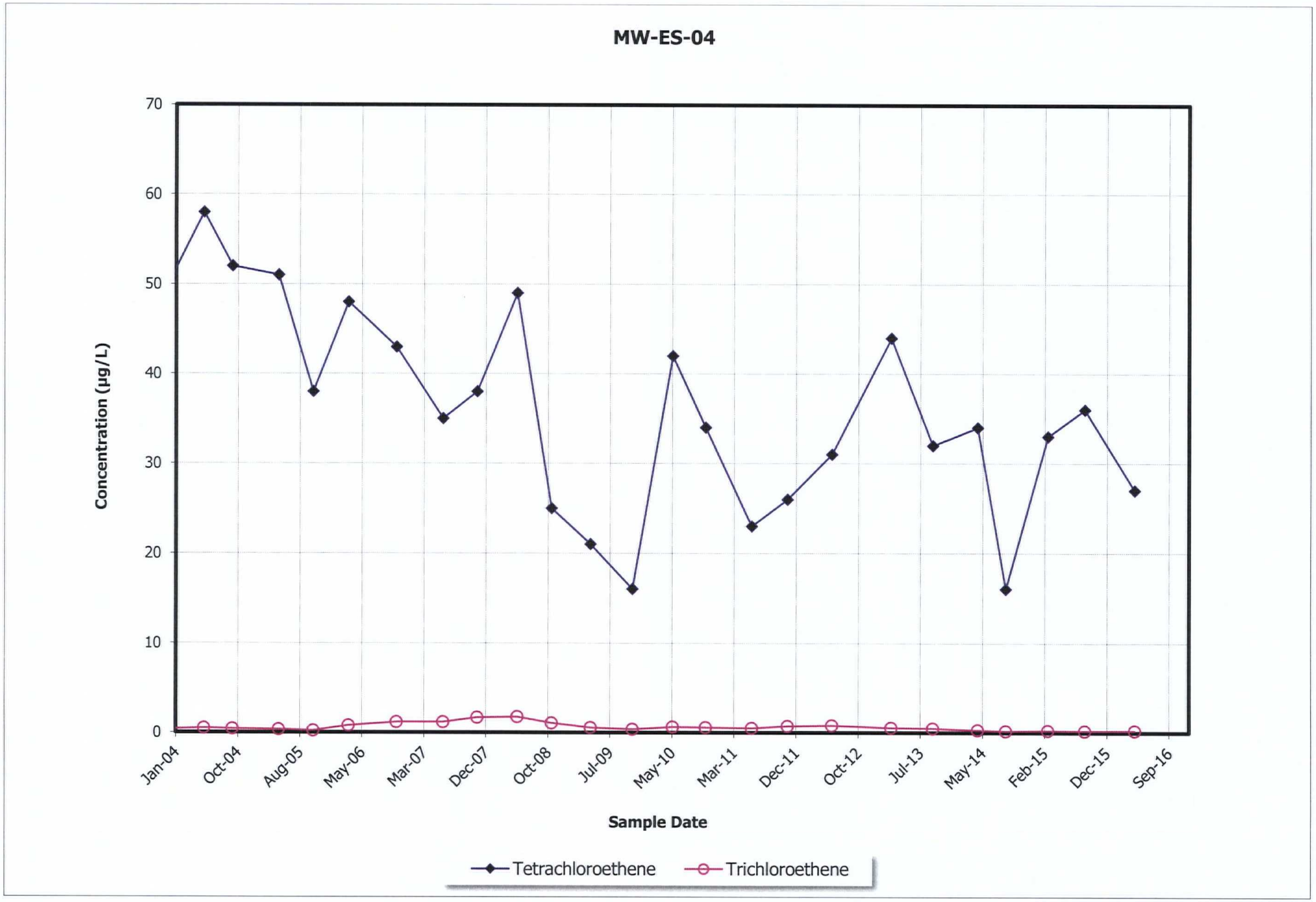

MW-96-15
Concentration (µg/L)
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
Jan-04
Oct-04
Aug-05
May-06
Mar-07
Dec-07
Oct-08
Jul-09
May-10
Mar-11
Dec-11
Oct-12
Jul-13
May-14
Feb-15
Dec-15
Sep-16
Sample Date
Tetrachloroethene
Trichloroethene

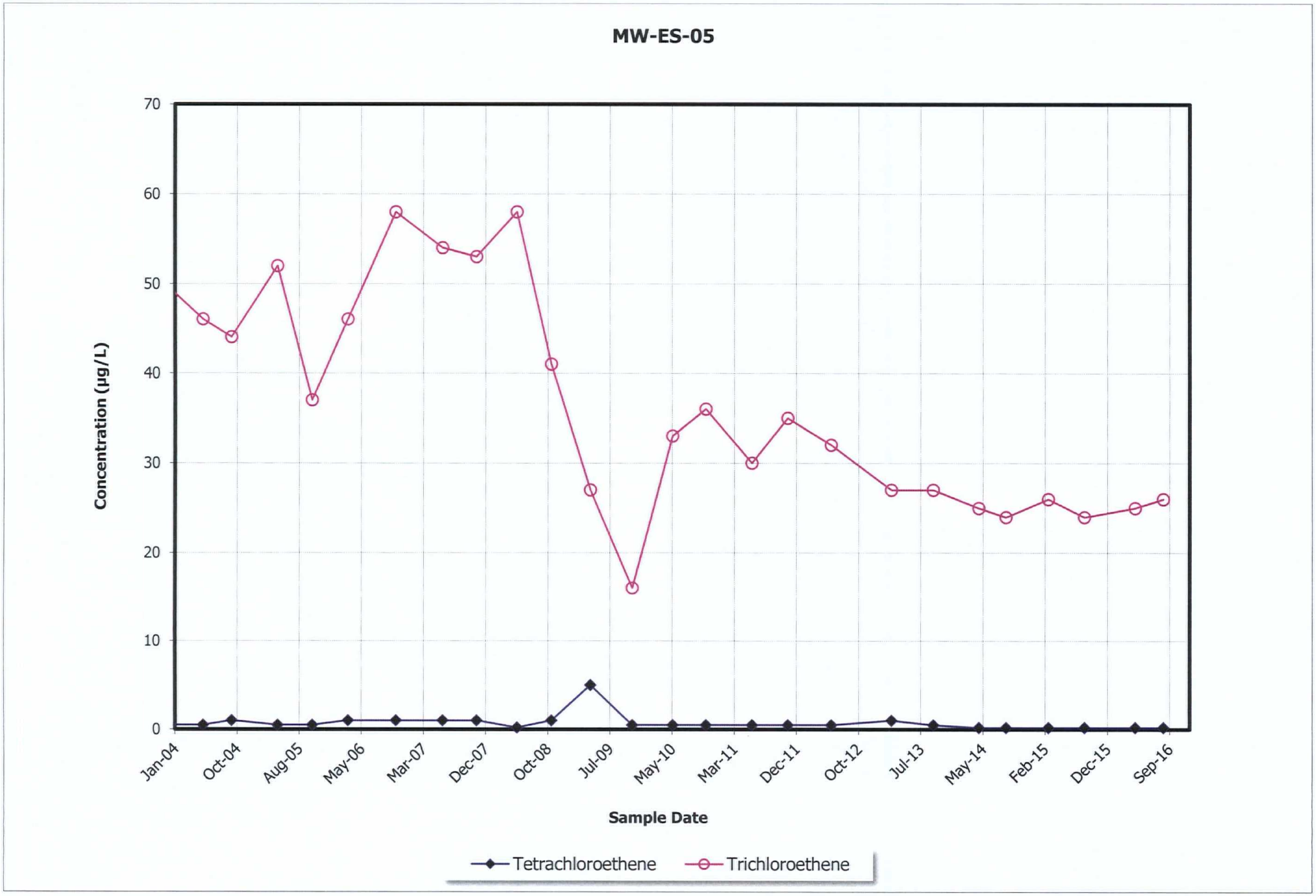

MW-96-16
Concentration (µg/L)
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
Jan-04
Oct-04
Aug-05
May-06
Mar-07
Dec-07
Oct-08
Jul-09
May-10
Mar-11
Dec-11
Oct-12
Jul-13
May-14
Feb-15
Dec-15
Sep-16
Sample Date
Tetrachloroethene
Trichloroethene

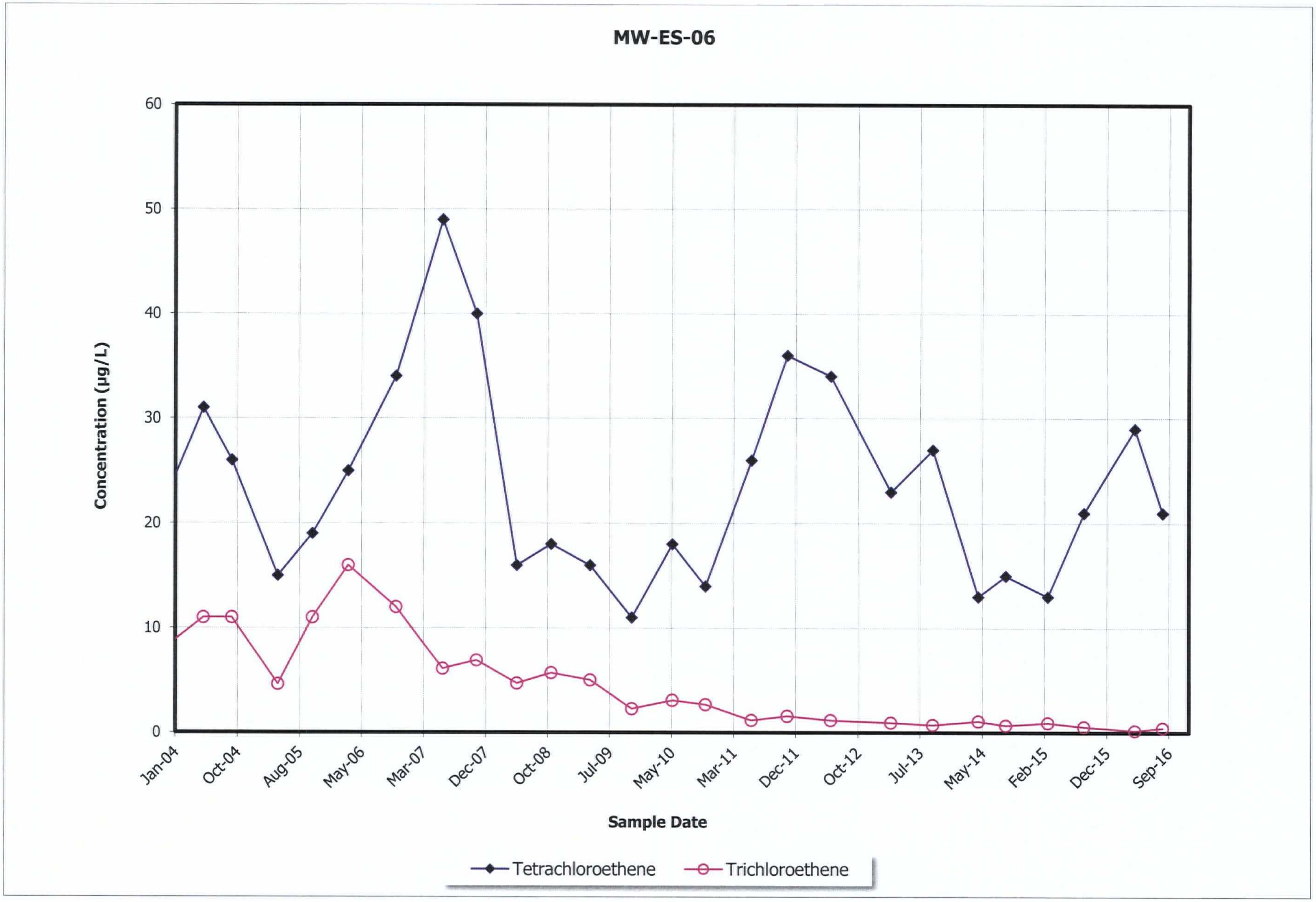

MW-96-17
Concentration (µg/L)
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
Jan-04
Oct-04
Aug-05
May-06
Mar-07
Dec-07
Oct-08
Jul-09
May-10
Mar-11
Dec-11
Oct-12
Jul-13
May-14
Feb-15
Dec-15
Sep-16
Sample Date
Tetrachloroethene
Trichloroethene

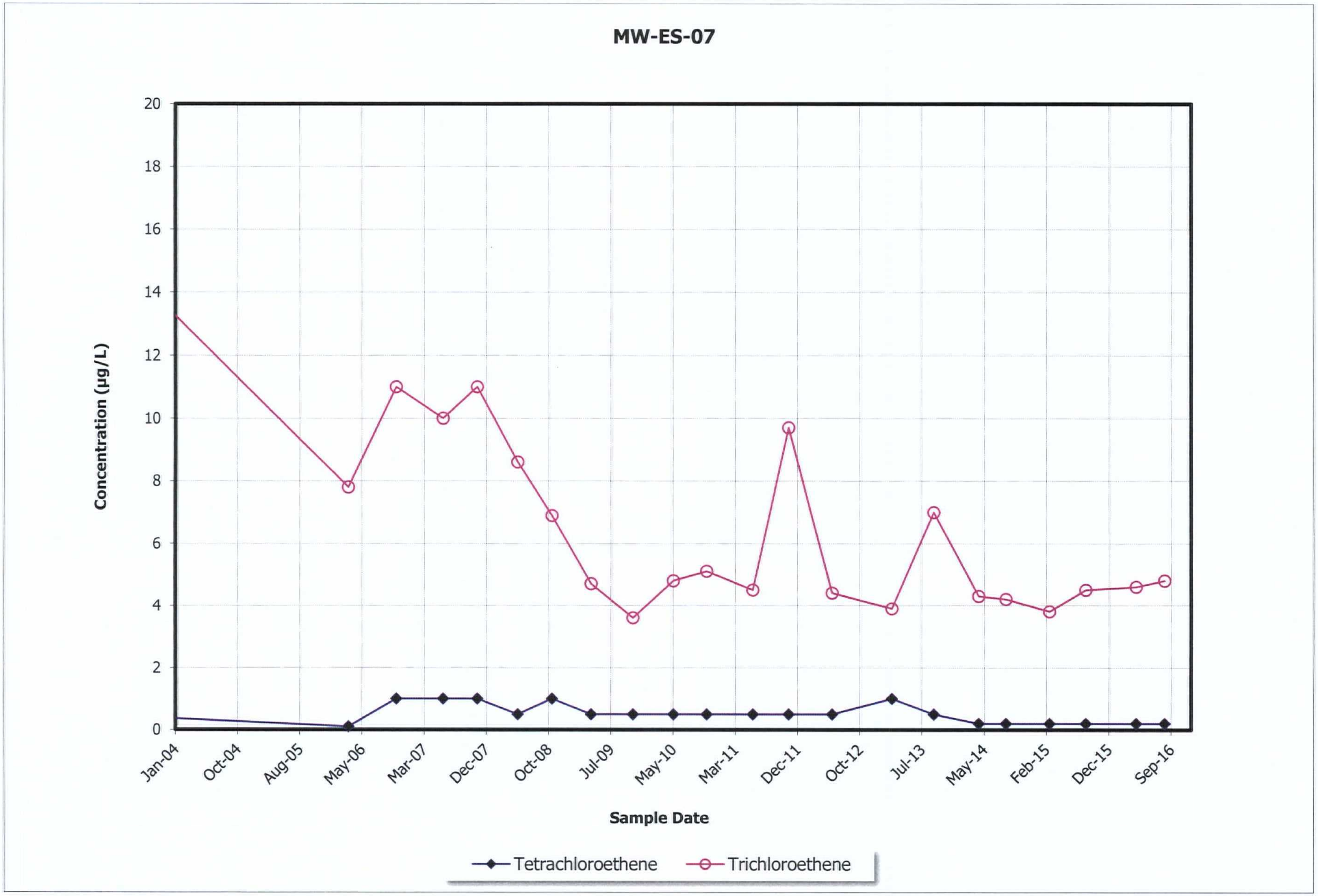

MW-ES-02
100
90
80
70
60
50
40
30
20
10
0
Concentration (µg/L)
Jan-04
Oct-04
Aug-05
May-06
Mar-07
Dec-07
Oct-08
Jul-09
May-10
Mar-11
Dec-11
Oct-12
Jul-13
May-14
Feb-15
Dec-15
Sep-16
Sample Date
Tetrachloroethene
Trichloroethene


MW-ES-03
Concentration (µg/L)
50
45
40
35
30
25
20
15
10
5
0
Jan-04
Oct-04
Aug-05
May-06
Mar-07
Dec-07
Oct-08
Jul-09
May-10
Mar-11
Dec-11
Oct-12
Jul-13
May-14
Feb-15
Dec-15
Sep-16
Sample Date
Tetrachloroethene
Trichloroethene

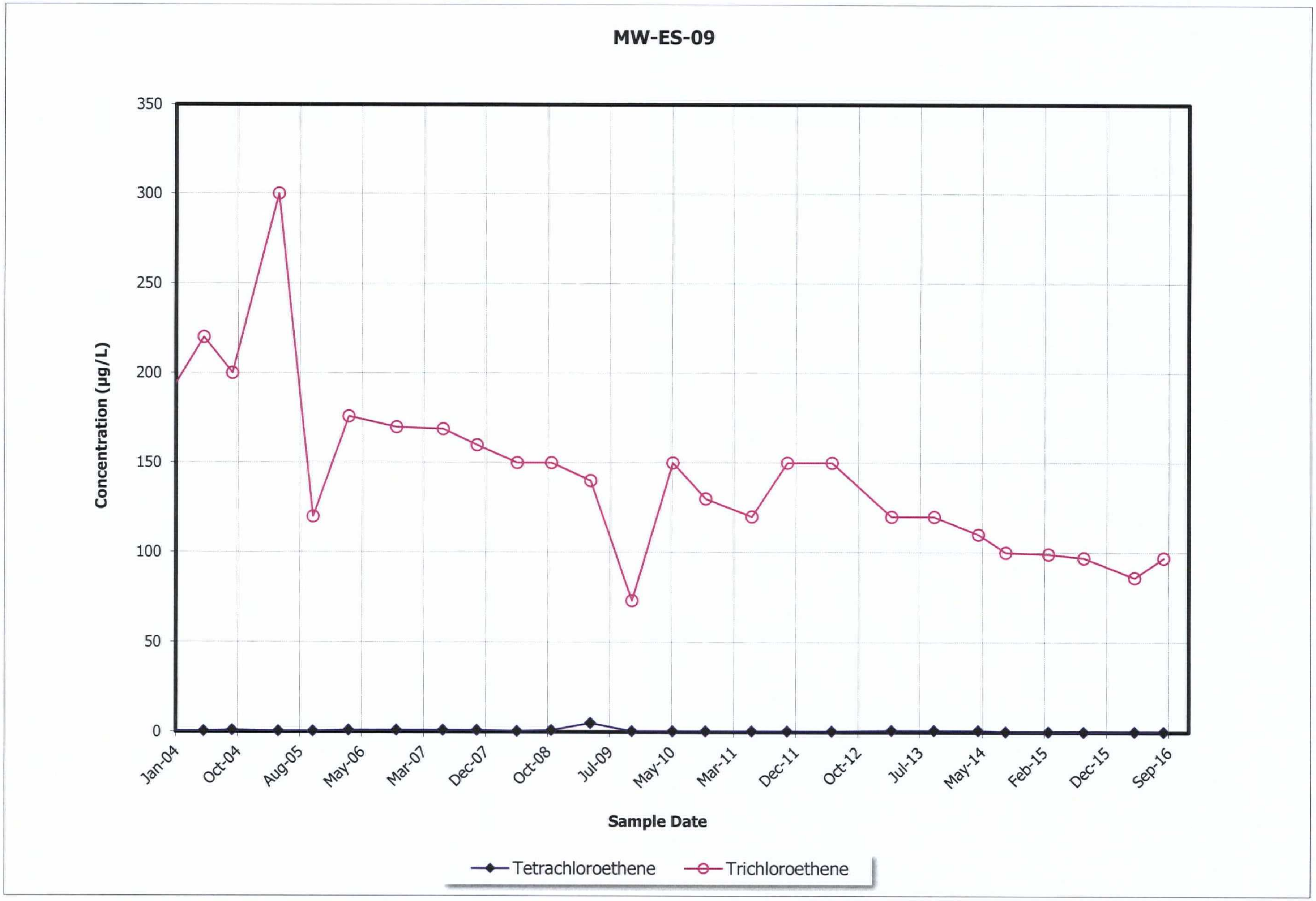

MW-ES-04
Concentration (µg/L)
70
60
50
40
30
20
10
0
Jan-04
Oct-04
Aug-05
May-06
Mar-07
Dec-07
Oct-08
Jul-09
May-10
Mar-11
Dec-11
Oct-12
Jul-13
May-14
Feb-15
Dec-15
Sep-16
Sample Date
Tetrachloroethene
Trichloroethene


MW-ES-05
Concentration (µg/L)
70
60
50
40
30
20
10
0
Jan-04
Oct-04
Aug-05
May-06
Mar-07
Dec-07
Oct-08
Jul-09
May-10
Mar-11
Dec-11
Oct-12
Jul-13
May-14
Feb-15
Dec-15
Sep-16
Sample Date
Tetrachloroethene
Trichloroethene

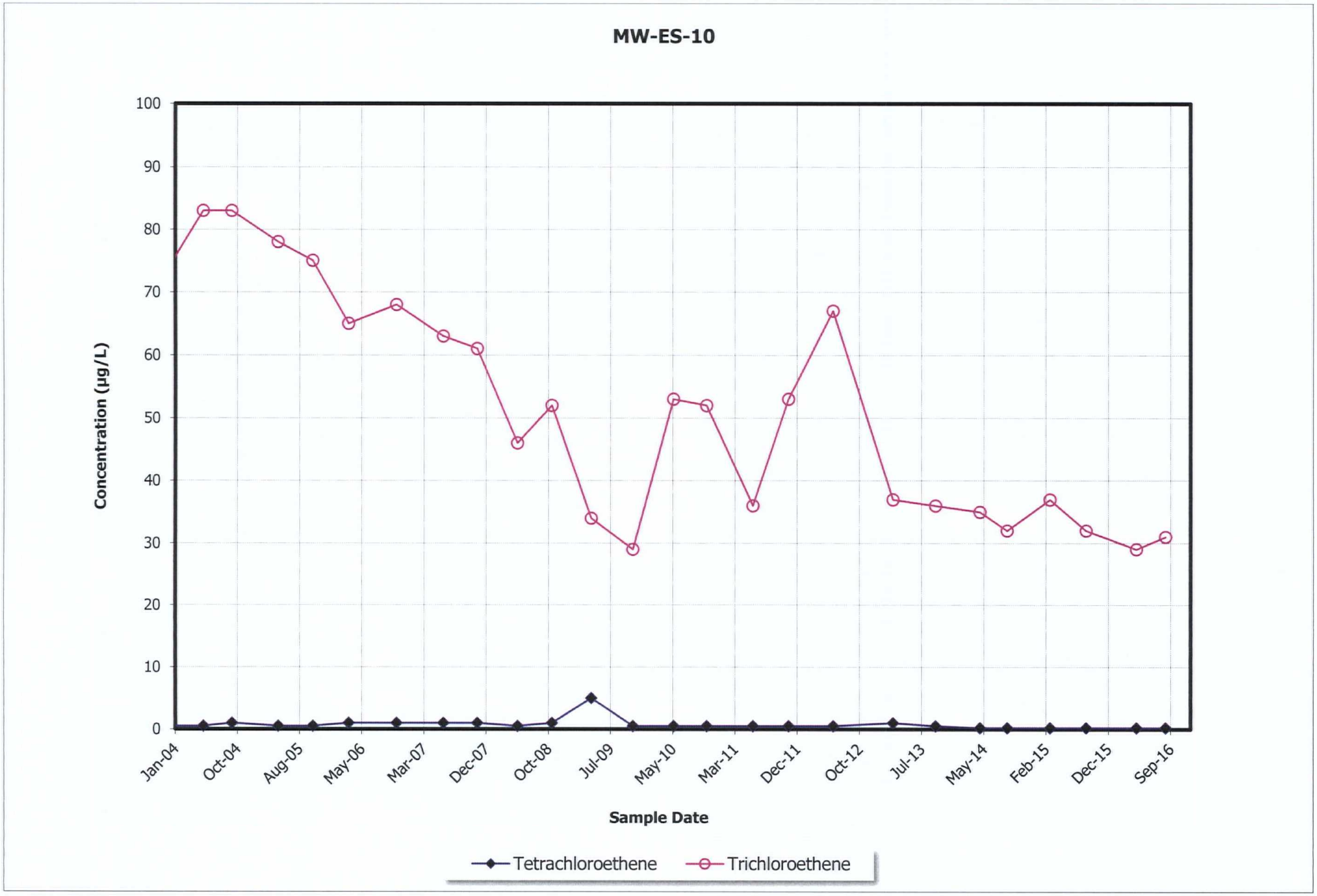

MW-ES-06
Concentration (µg/L)
60
50
40
30
20
10
0
Jan-04
Oct-04
Aug-05
May-06
Mar-07
Dec-07
Oct-08
Jul-09
May-10
Mar-11
Dec-11
Oct-12
Jul-13
May-14
Feb-15
Dec-15
Sep-16
Sample Date
Tetrachloroethene
Trichloroethene

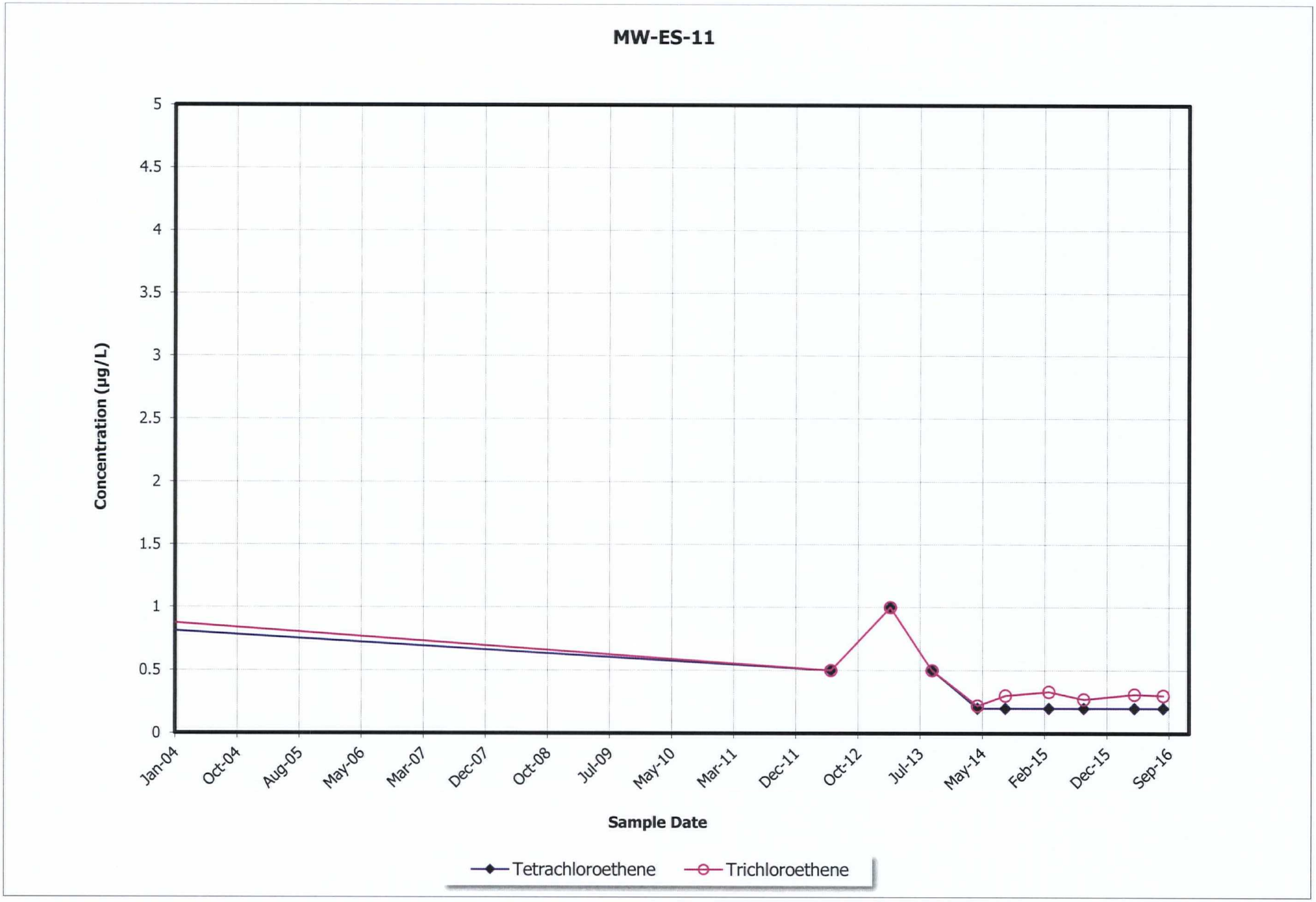


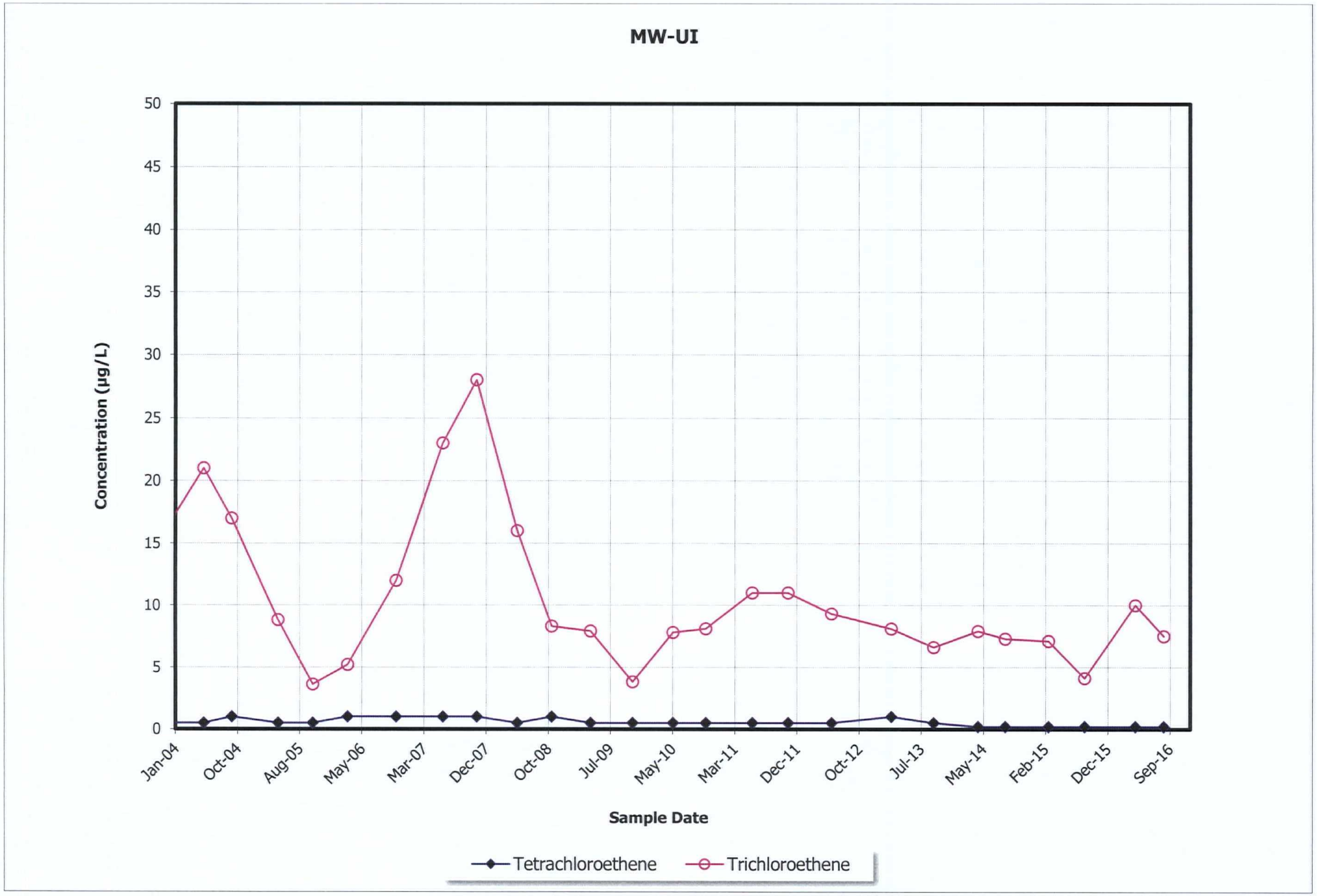
MW-ES-07
Concentration (µg/L)
0
2
4
6
8
10
12
14
16
18
20
Jan-04
Oct-04
Aug-05
May-06
Mar-07
Dec-07
Oct-08
Jul-09
May-10
Mar-11
Dec-11
Oct-12
Jul-13
May-14
Feb-15
Dec-15
Sep-16
Sample Date
Tetrachloroethene
Trichloroethene



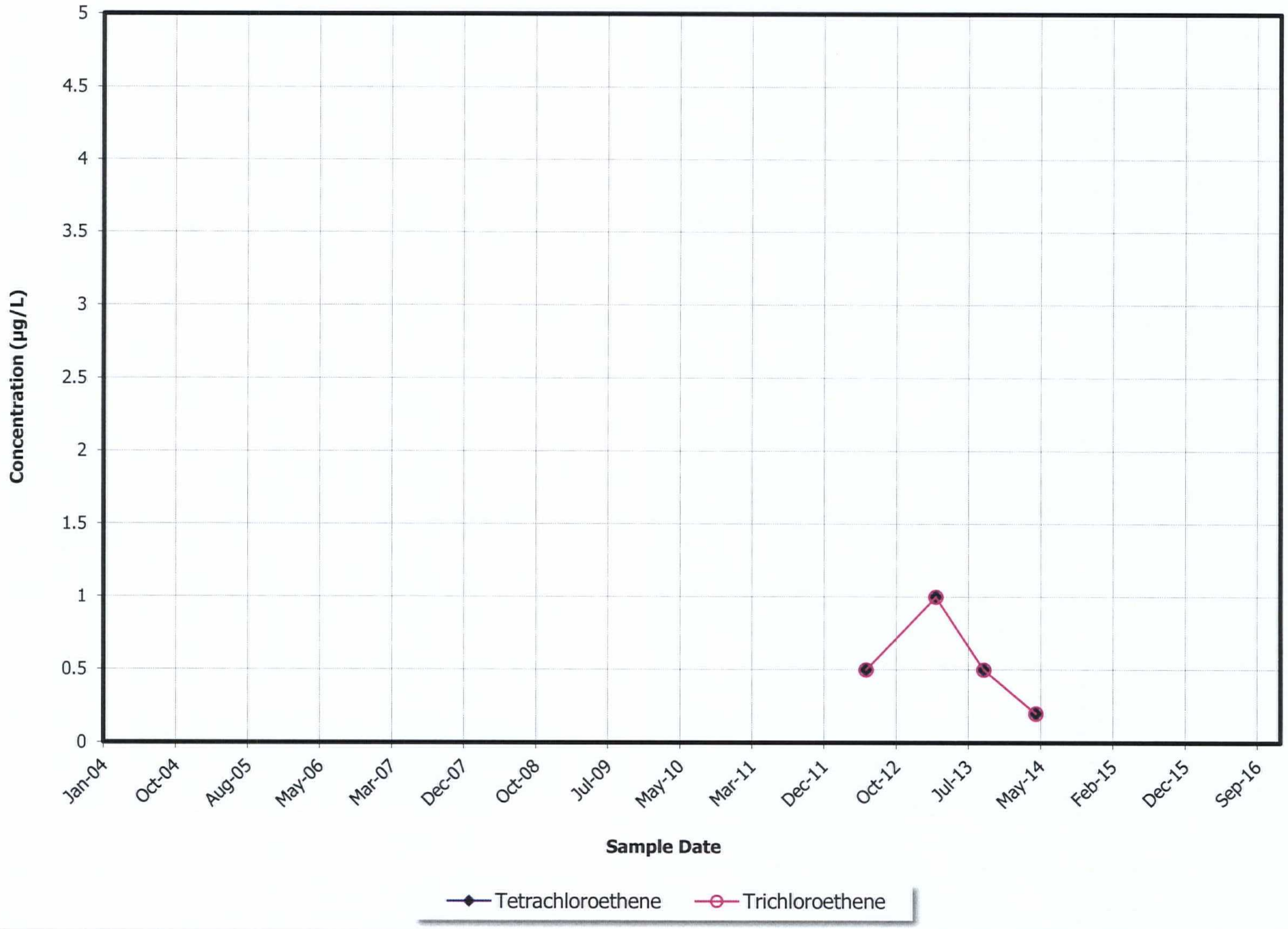
MW-ES-09
Concentration (µg/L)
350
300
250
200
150
100
50
0
Jan-04
Oct-04
Aug-05
May-06
Mar-07
Dec-07
Oct-08
Jul-09
May-10
Mar-11
Dec-11
Oct-12
Jul-13
May-14
Feb-15
Dec-15
Sep-16
Sample Date
Tetrachloroethene
Trichloroethene

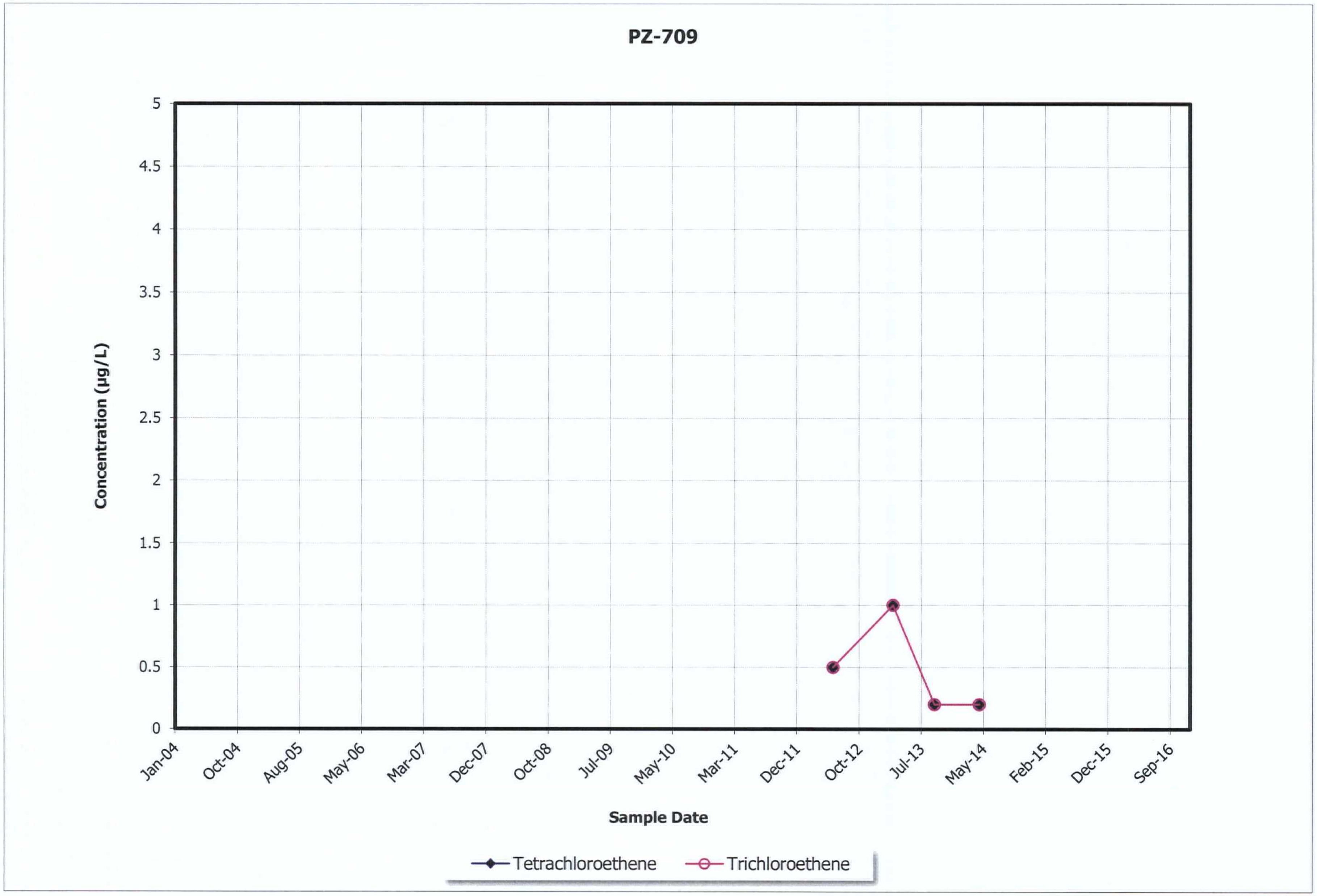

MW-ES-10
Concentration (µg/L)
100
90
80
70
60
50
40
30
20
10
0
Jan-04
Oct-04
Aug-05
May-06
Mar-07
Dec-07
Oct-08
Jul-09
May-10
Mar-11
Dec-11
Oct-12
Jul-13
May-14
Feb-15
Dec-15
Sep-16
Sample Date
Tetrachloroethene
Trichloroethene

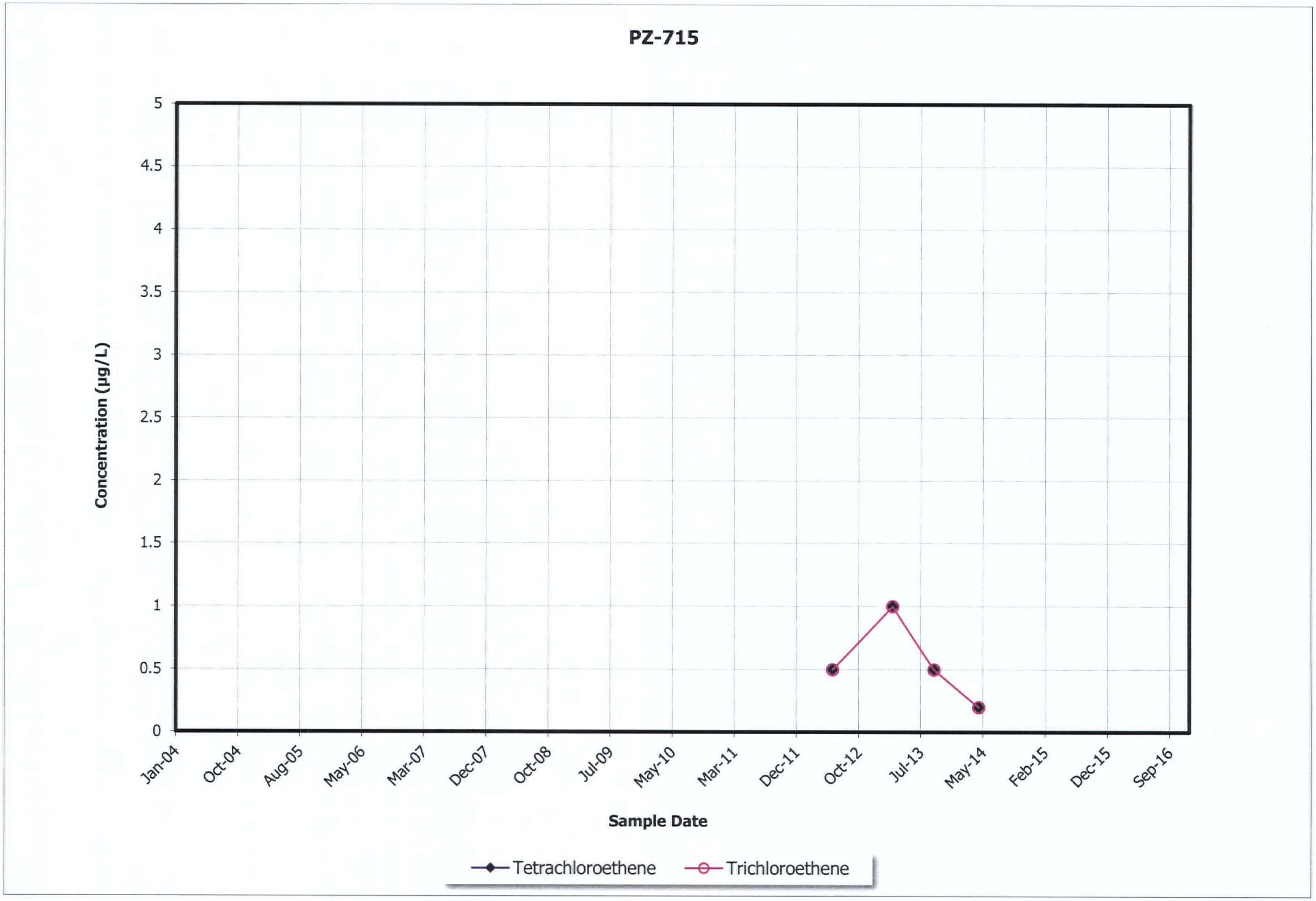

MW-ES-11
Concentration (µg/L)
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
Jan-04
Oct-04
Aug-05
May-06
Mar-07
Dec-07
Oct-08
Jul-09
May-10
Mar-11
Dec-11
Oct-12
Jul-13
May-14
Feb-15
Dec-15
Sep-16
Sample Date
Tetrachloroethene
Trichloroethene

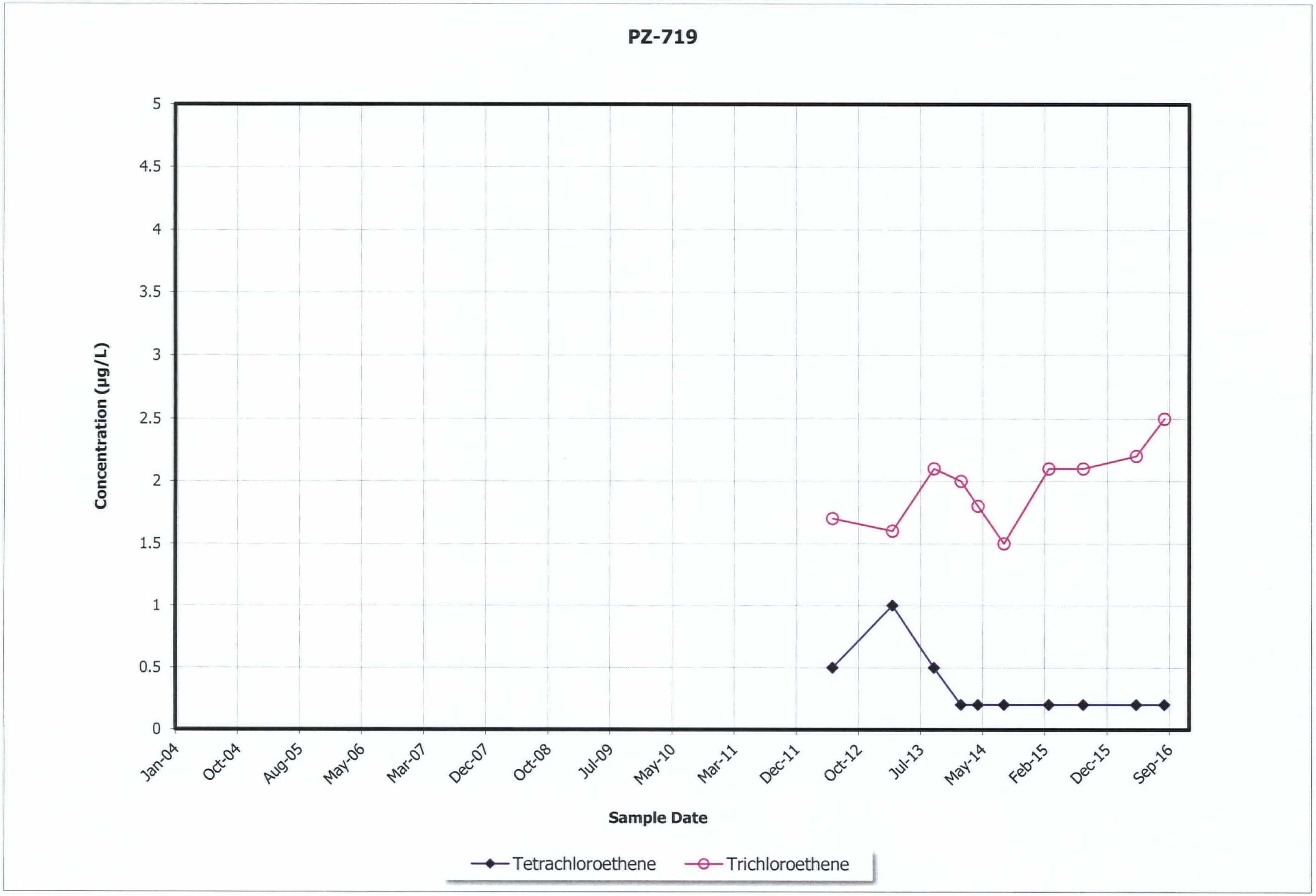

MW-UI
Concentration (µg/L)
50
45
40
35
30
25
20
15
10
5
0
Jan-04
Oct-04
Aug-05
May-06
Mar-07
Dec-07
Oct-08
Jul-09
May-10
Mar-11
Dec-11
Oct-12
Jul-13
May-14
Feb-15
Dec-15
Sep-16
Sample Date
Tetrachloroethene
Trichloroethene

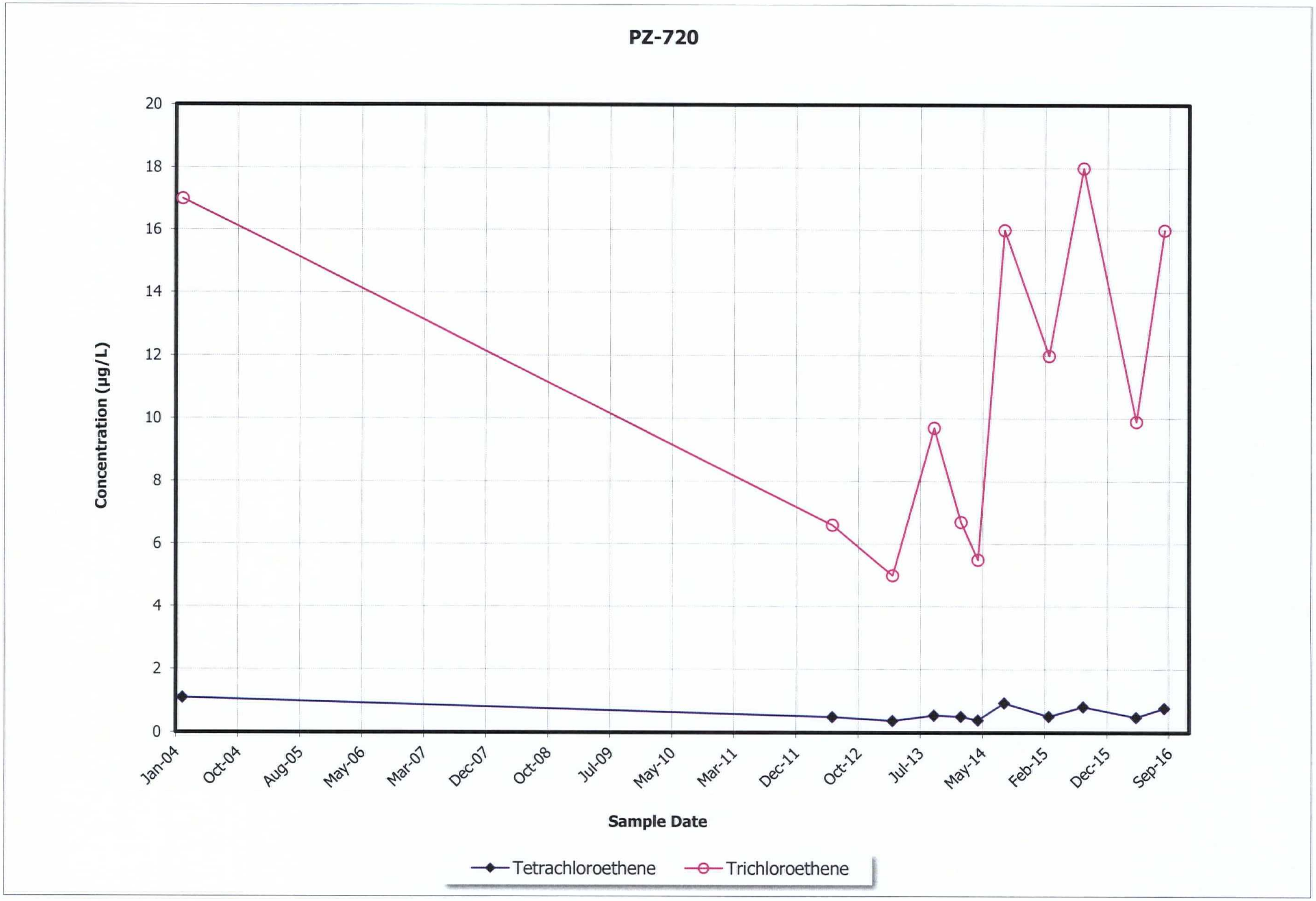
PZ-704

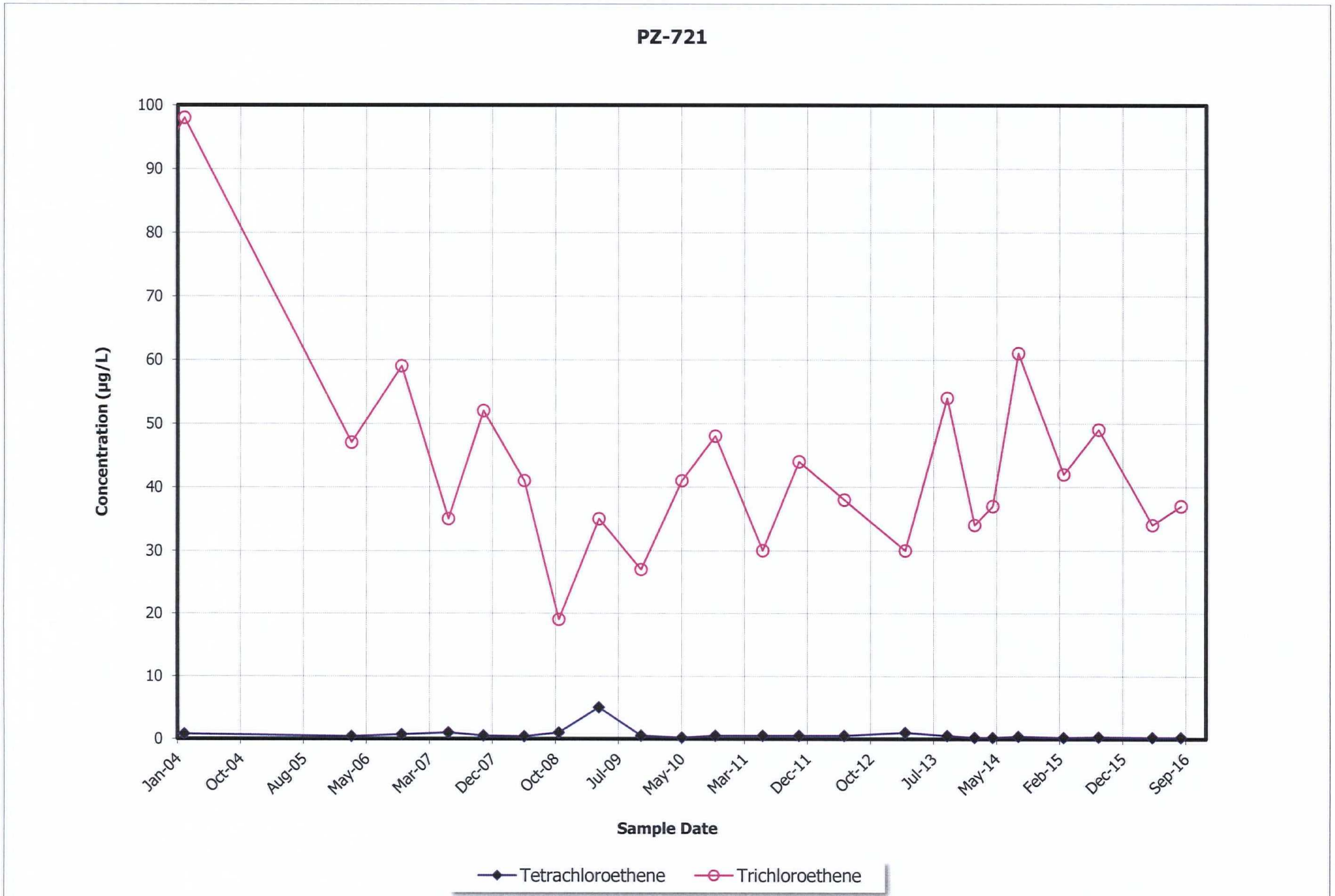

Concentration (µg/L)
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
Jan-04
Oct-04
Aug-05
May-06
Mar-07
Dec-07
Oct-08
Jul-09
May-10
Mar-11
Dec-11
Oct-12
Jul-13
May-14
Feb-15
Dec-15
Sep-16
Sample Date
Tetrachloroethene
Trichloroethene


PZ-709
Concentration (µg/L)
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
Jan-04
Oct-04
Aug-05
May-06
Mar-07
Dec-07
Oct-08
Jul-09
May-10
Mar-11
Dec-11
Oct-12
Jul-13
May-14
Feb-15
Dec-15
Sep-16
Sample Date
Tetrachloroethene
Trichloroethene

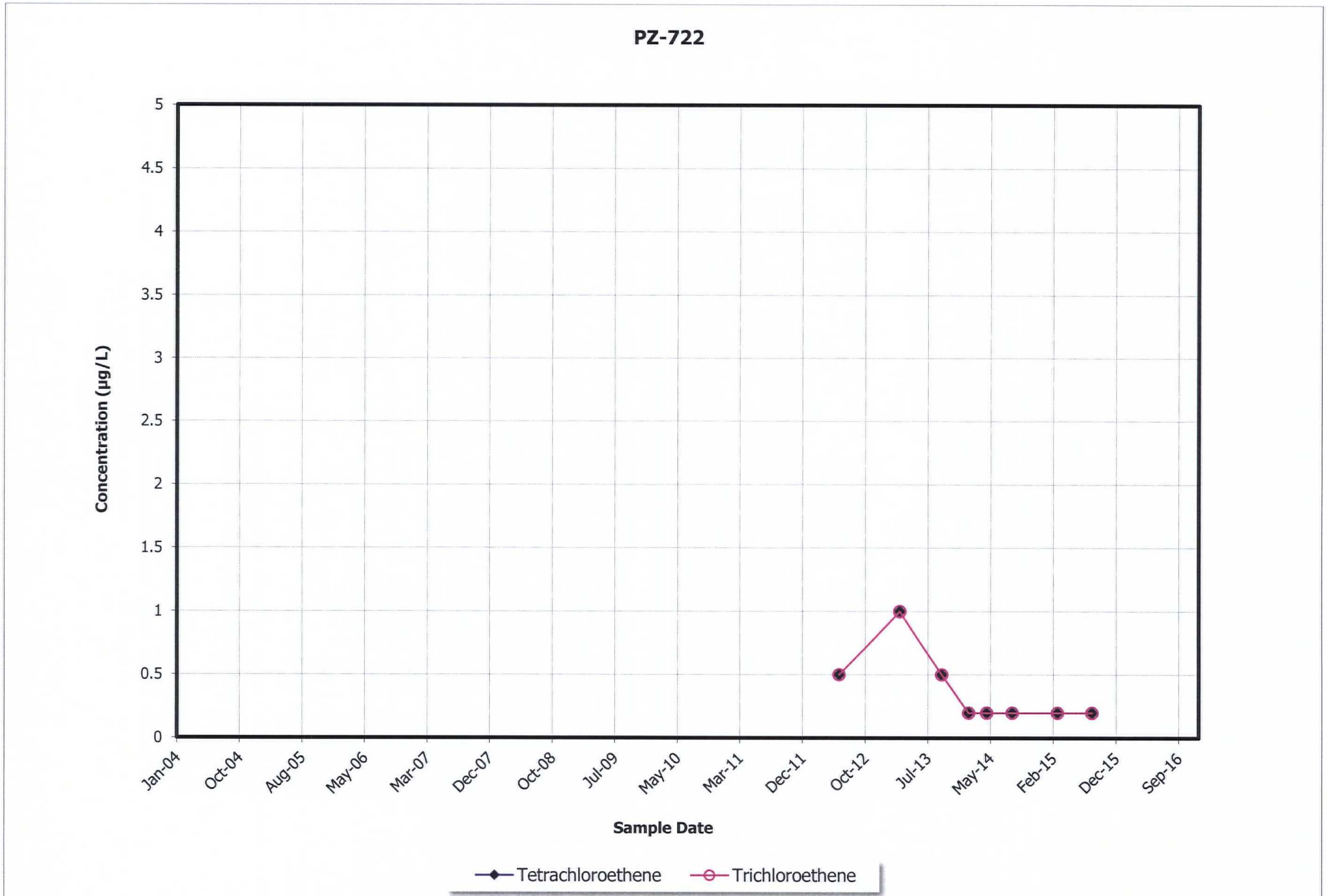

PZ-715
Concentration (µg/L)
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
Jan-04
Oct-04
Aug-05
May-06
Mar-07
Dec-07
Oct-08
Jul-09
May-10
Mar-11
Dec-11
Oct-12
Jul-13
May-14
Feb-15
Dec-15
Sep-16
Sample Date
Tetrachloroethene
Trichloroethene

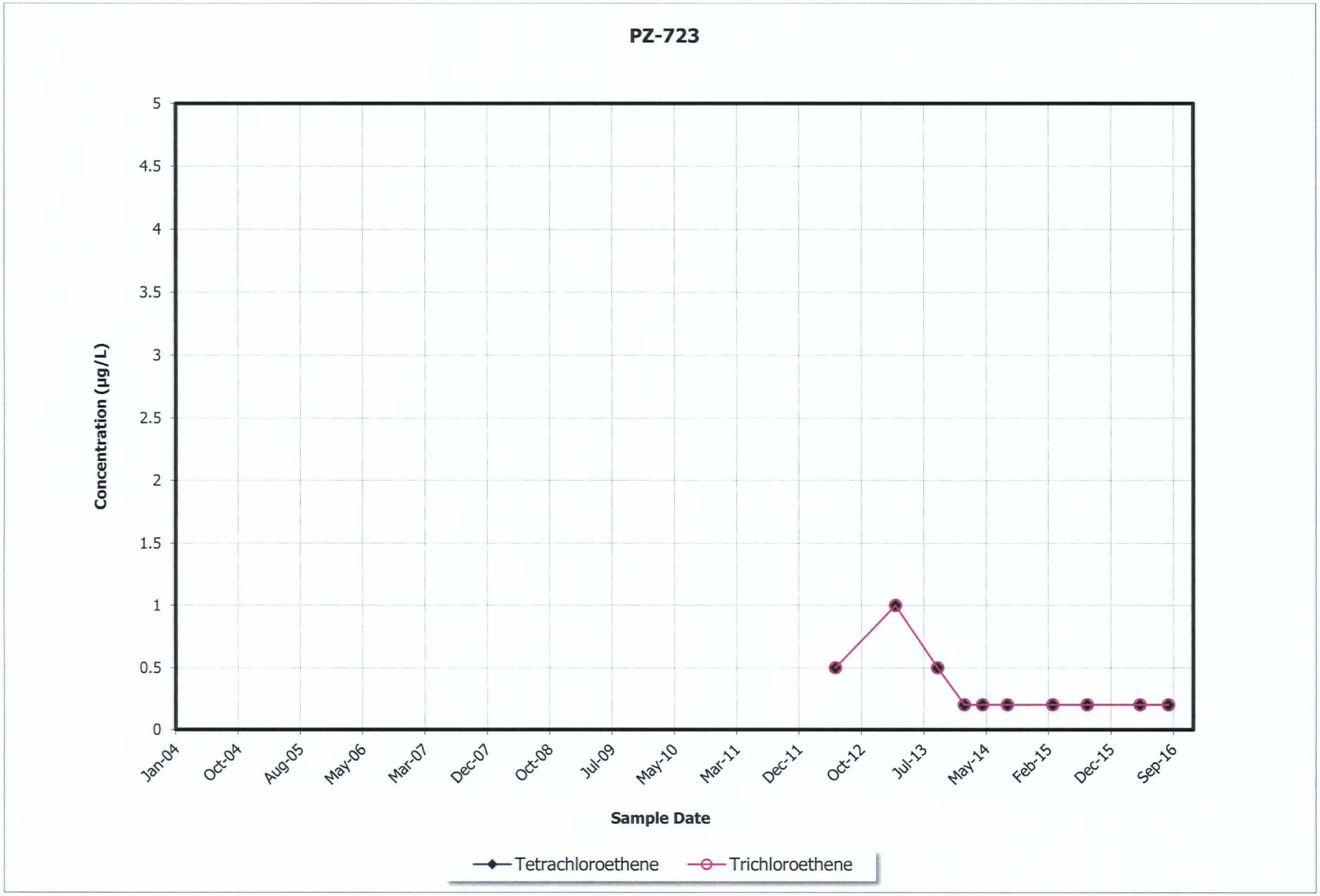

PZ-719
Concentration (µg/L)
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
Jan-04
Oct-04
Aug-05
May-06
Mar-07
Dec-07
Oct-08
Jul-09
May-10
Mar-11
Dec-11
Oct-12
Jul-13
May-14
Feb-15
Dec-15
Sep-16
Sample Date
Tetrachloroethene
Trichloroethene

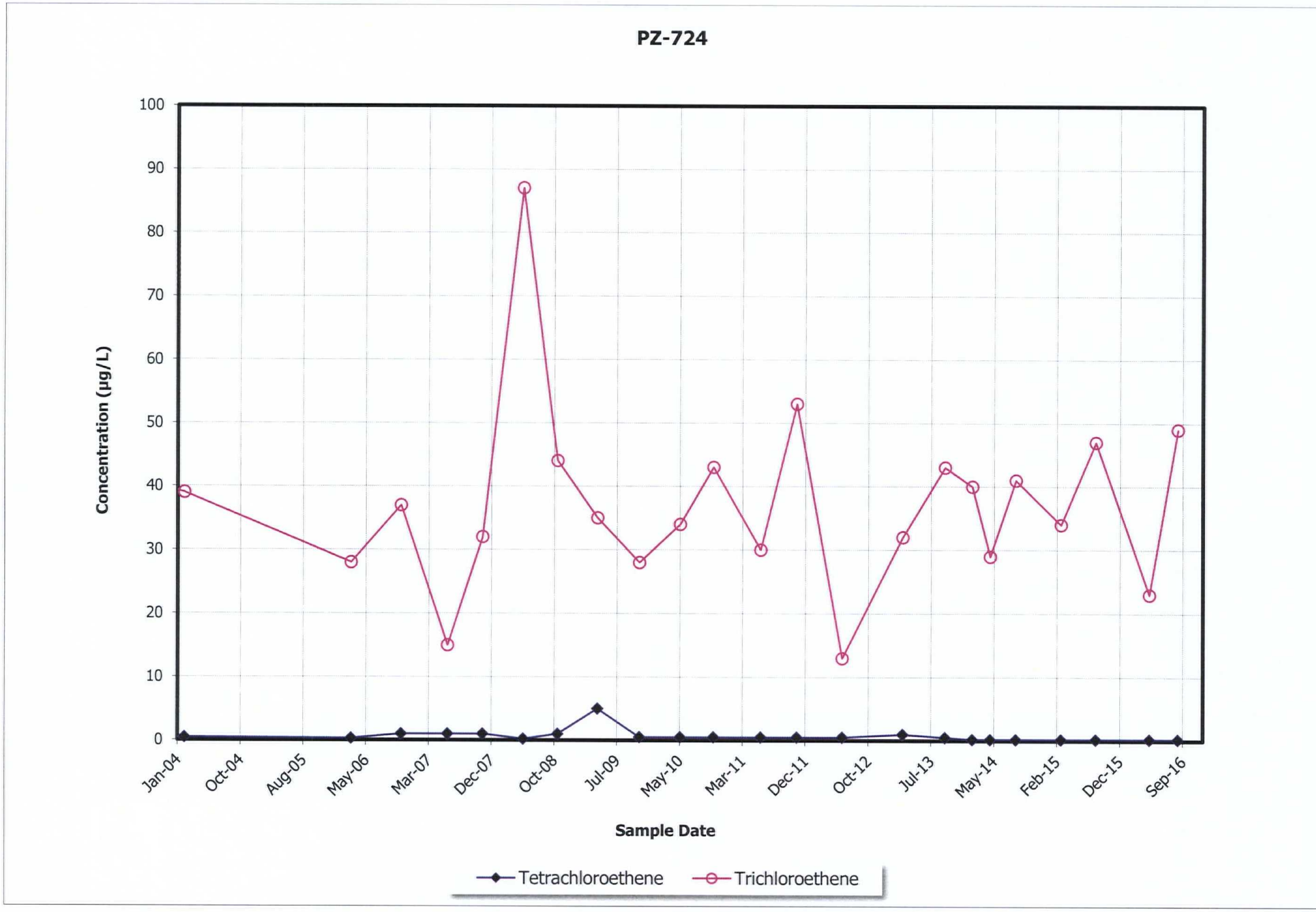

PZ-720
Concentration (µg/L)
20
18
16
14
12
10
8
6
4
2
0
Jan-04
Oct-04
Aug-05
May-06
Mar-07
Dec-07
Oct-08
Jul-09
May-10
Mar-11
Dec-11
Oct-12
Jul-13
May-14
Feb-15
Dec-15
Sep-16
Sample Date
Tetrachloroethene
Trichloroethene

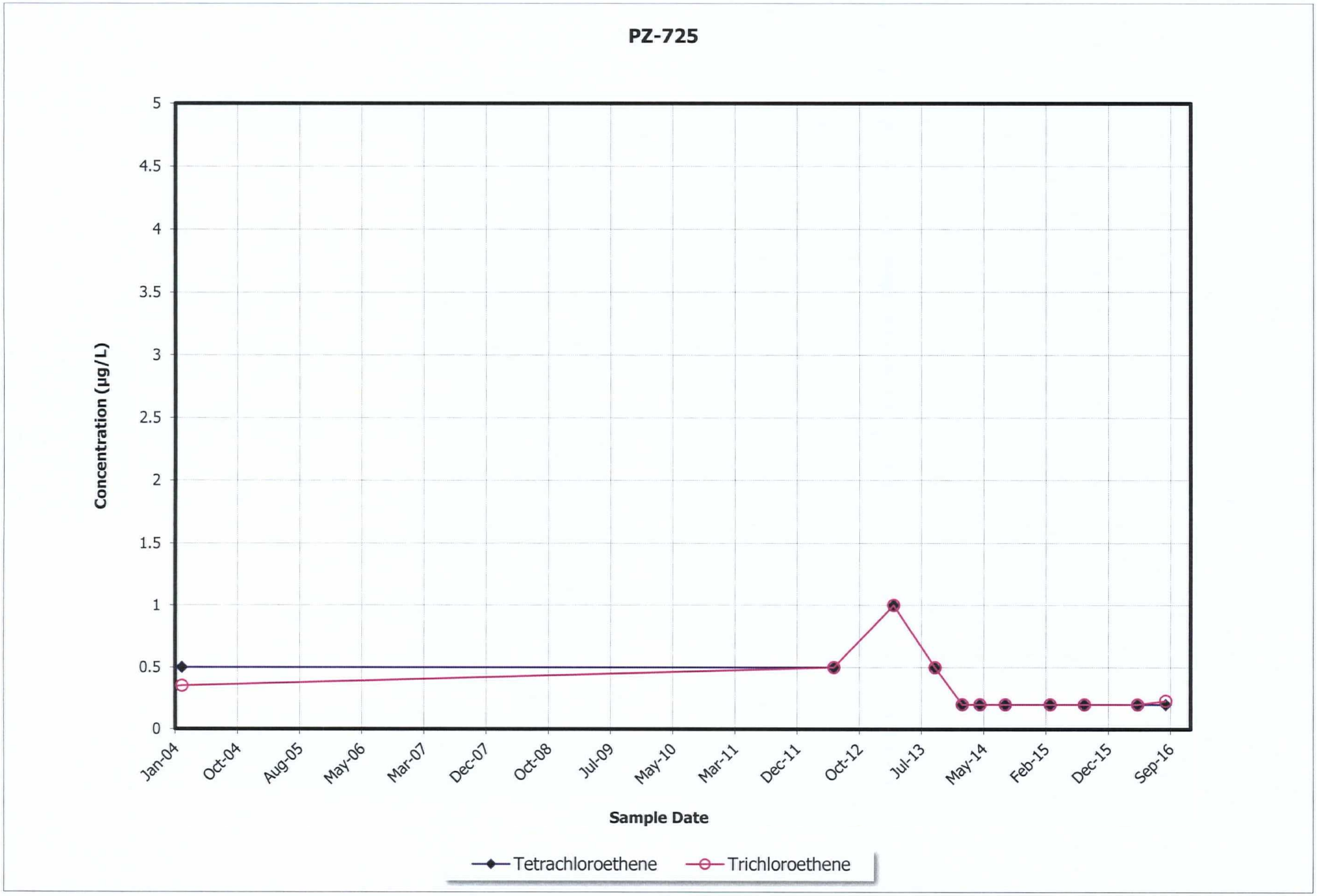


PZ-721
Concentration (µg/L)
100
90
80
70
60
50
40
30
20
10
0
Jan-04
Oct-04
Aug-05
May-06
Mar-07
Dec-07
Oct-08
Jul-09
May-10
Mar-11
Dec-11
Oct-12
Jul-13
May-14
Feb-15
Dec-15
Sep-16
Sample Date
Tetrachloroethene
Trichloroethene

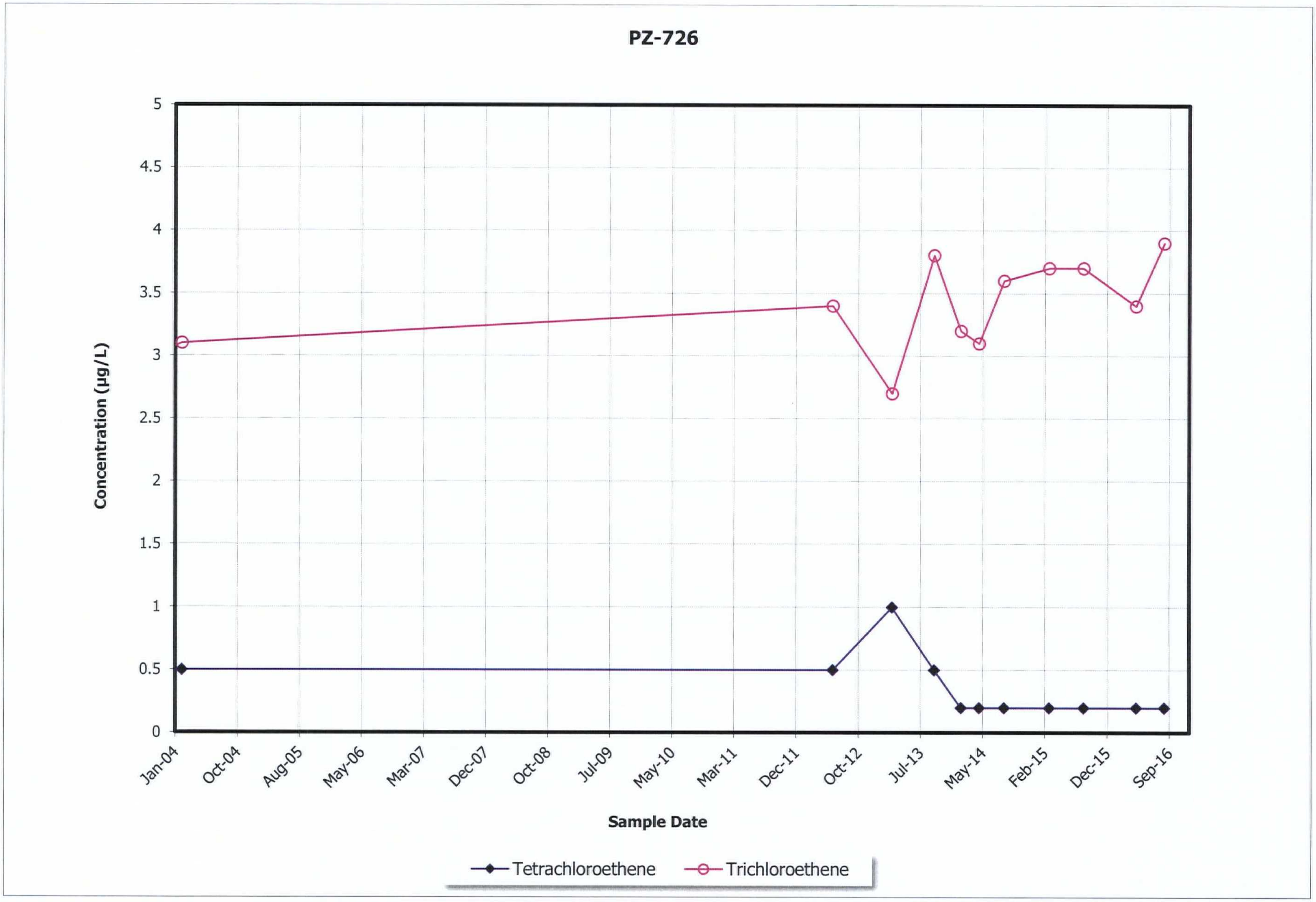

PZ-722
Concentration (µg/L)
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
Jan-04
Oct-04
Aug-05
May-06
Mar-07
Dec-07
Oct-08
Jul-09
May-10
Mar-11
Dec-11
Oct-12
Jul-13
May-14
Feb-15
Dec-15
Sep-16
Sample Date
Tetrachloroethene
Trichloroethene


PZ-723
Concentration (µg/L)
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
Jan-04
Oct-04
Aug-05
May-06
Mar-07
Dec-07
Oct-08
Jul-09
May-10
Mar-11
Dec-11
Oct-12
Jul-13
May-14
Feb-15
Dec-15
Sep-16
Sample Date
Tetrachloroethene
Trichloroethene

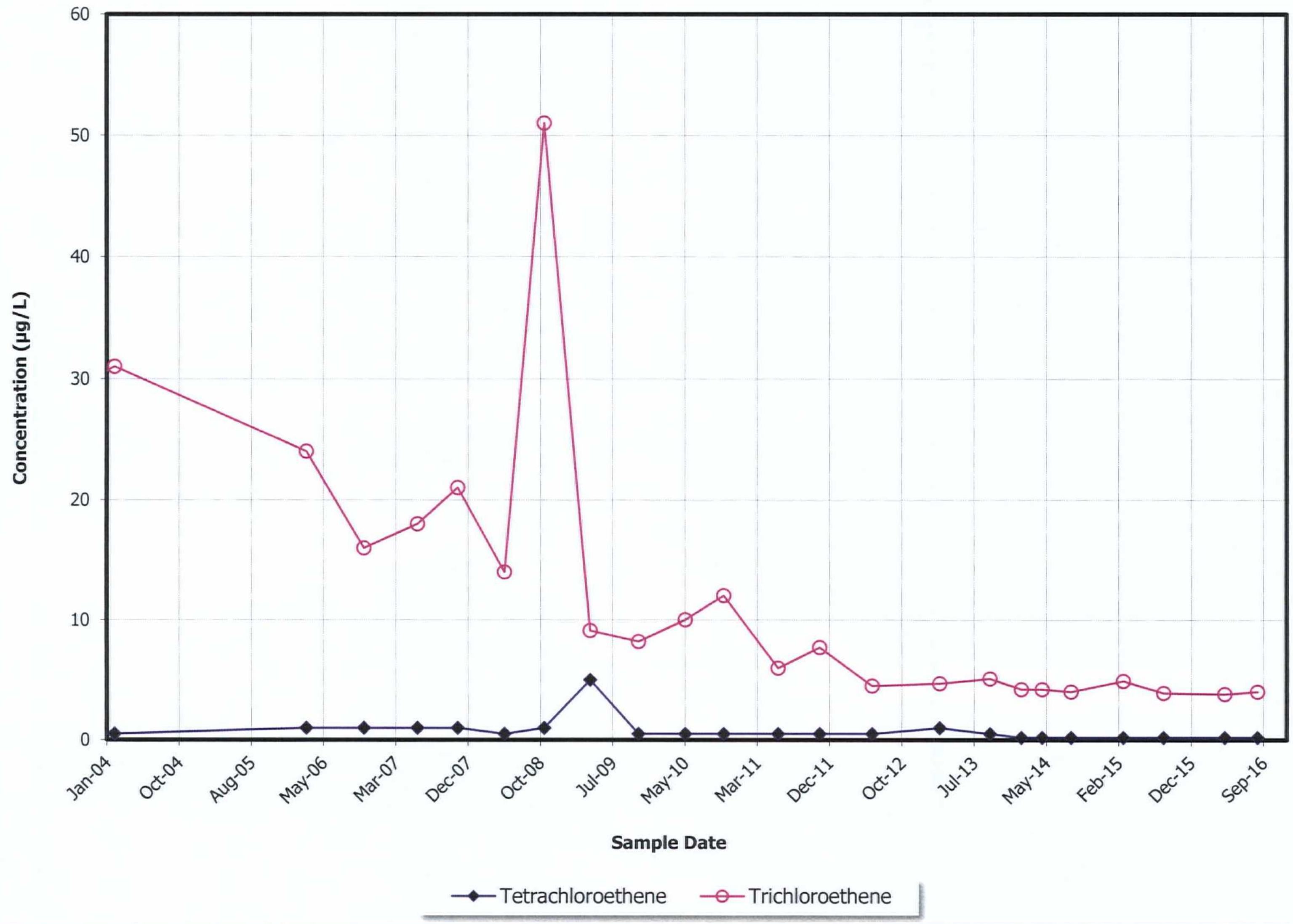

PZ-724
Concentration (µg/L)
100
90
80
70
60
50
40
30
20
10
0
Jan-04
Oct-04
Aug-05
May-06
Mar-07
Dec-07
Oct-08
Jul-09
May-10
Mar-11
Dec-11
Oct-12
Jul-13
May-14
Feb-15
Dec-15
Sep-16
Sample Date
Tetrachloroethene
Trichloroethene



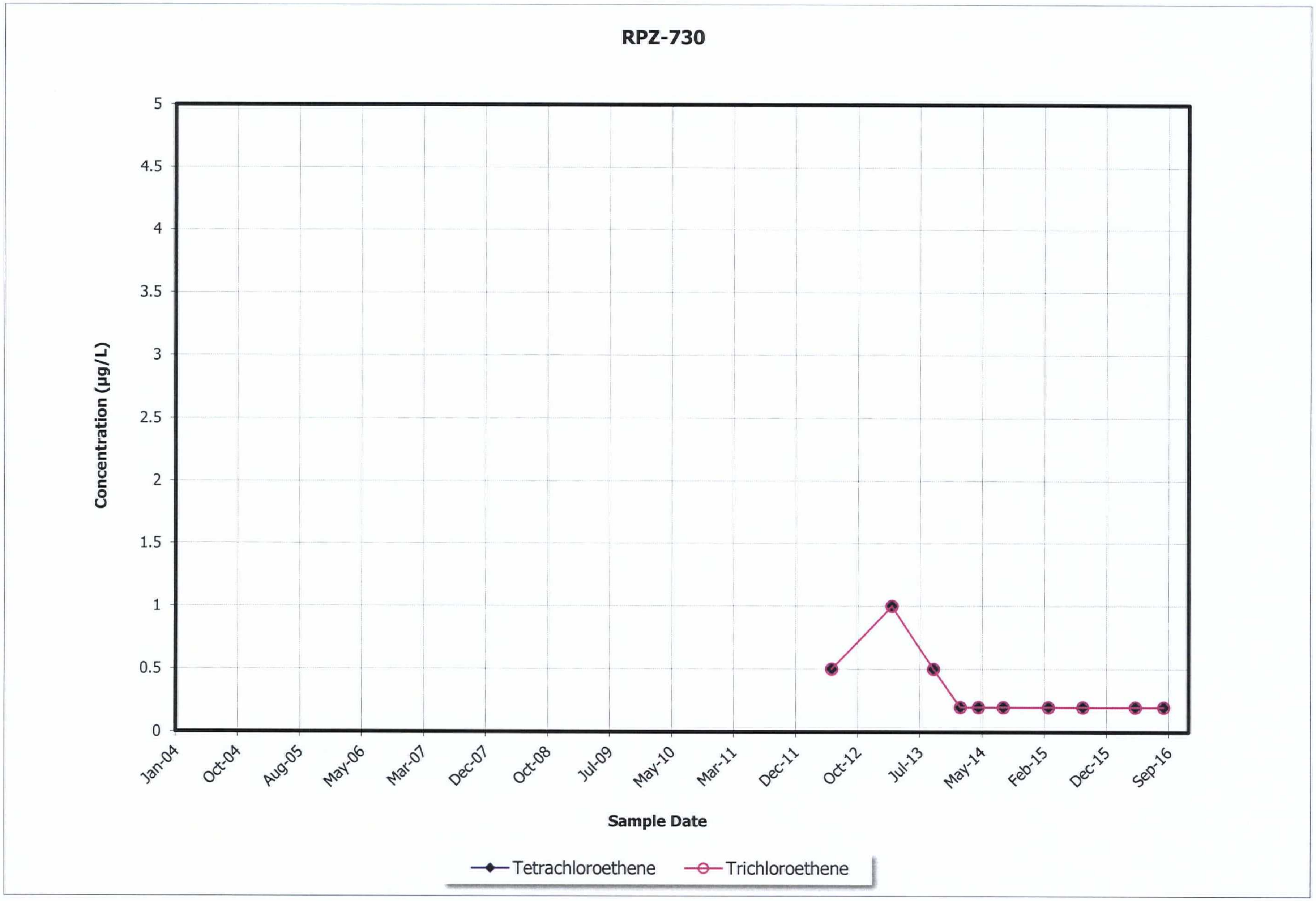
PZ-725
Concentration (µg/L)
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
Jan-04
Oct-04
Aug-05
May-06
Mar-07
Dec-07
Oct-08
Jul-09
May-10
Mar-11
Dec-11
Oct-12
Jul-13
May-14
Feb-15
Dec-15
Sep-16
Sample Date
Tetrachloroethene
Trichloroethene

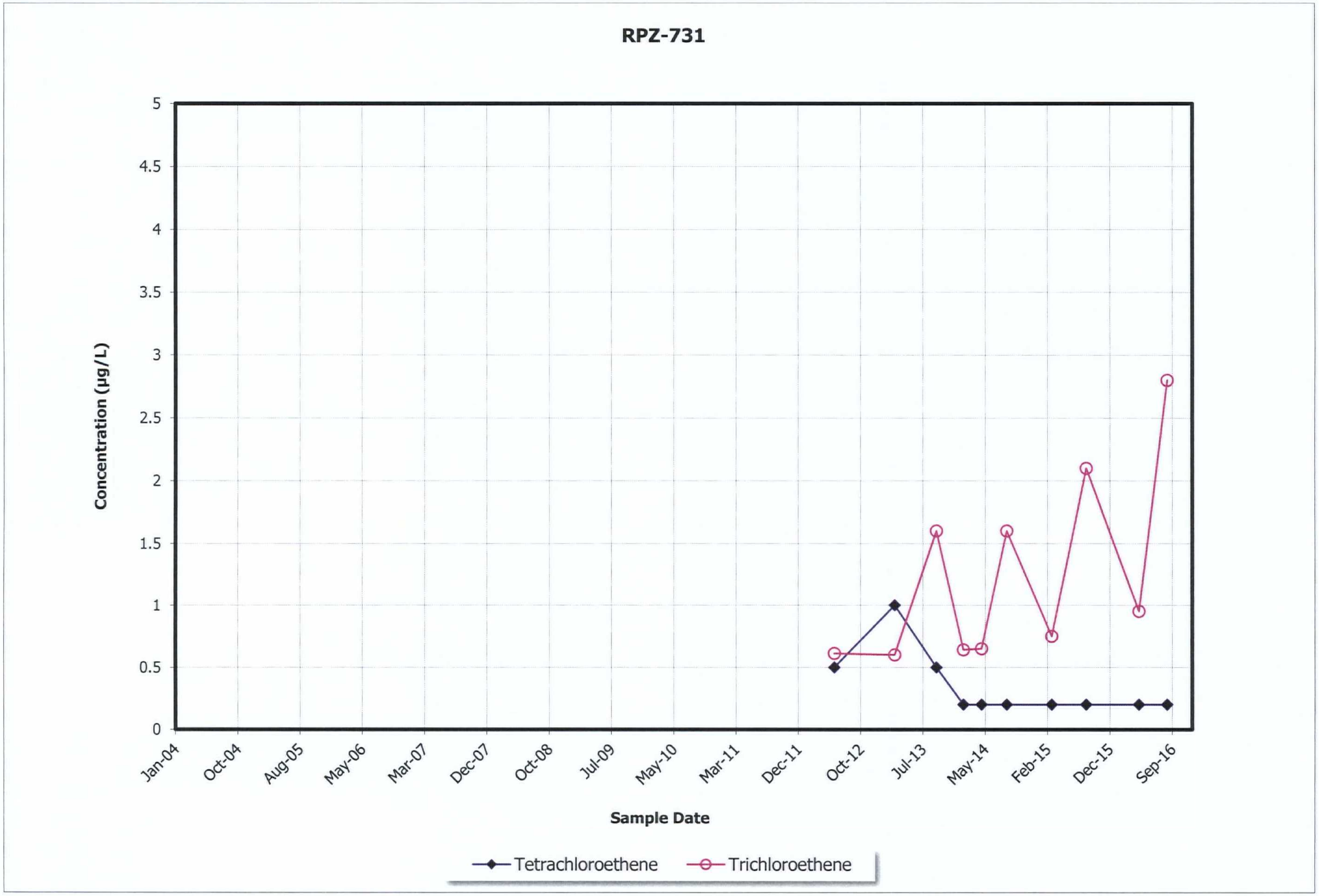

PZ-726
Concentration (µg/L)
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
Jan-04
Oct-04
Aug-05
May-06
Mar-07
Dec-07
Oct-08
Jul-09
May-10
Mar-11
Dec-11
Oct-12
Jul-13
May-14
Feb-15
Dec-15
Sep-16
Sample Date
Tetrachloroethene
Trichloroethene

PZ-728

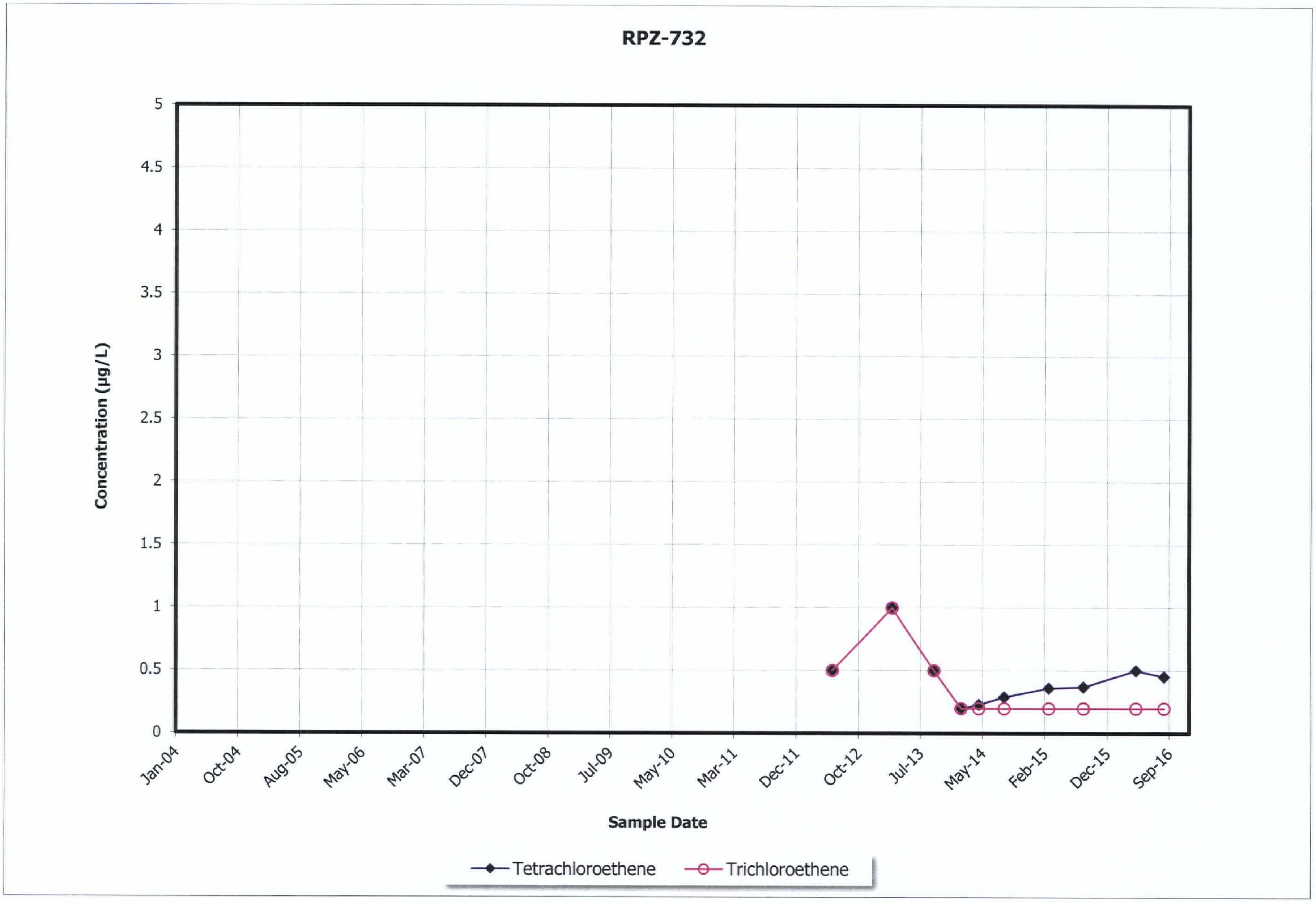


Concentration (µg/L)
0
10
20
30
40
50
60
Jan-04
Oct-04
Aug-05
May-06
Mar-07
Dec-07
Oct-08
Jul-09
May-10
Mar-11
Dec-11
Oct-12
Jul-13
May-14
Feb-15
Dec-15
Sep-16
Sample Date
Tetrachloroethene
Trichloroethene

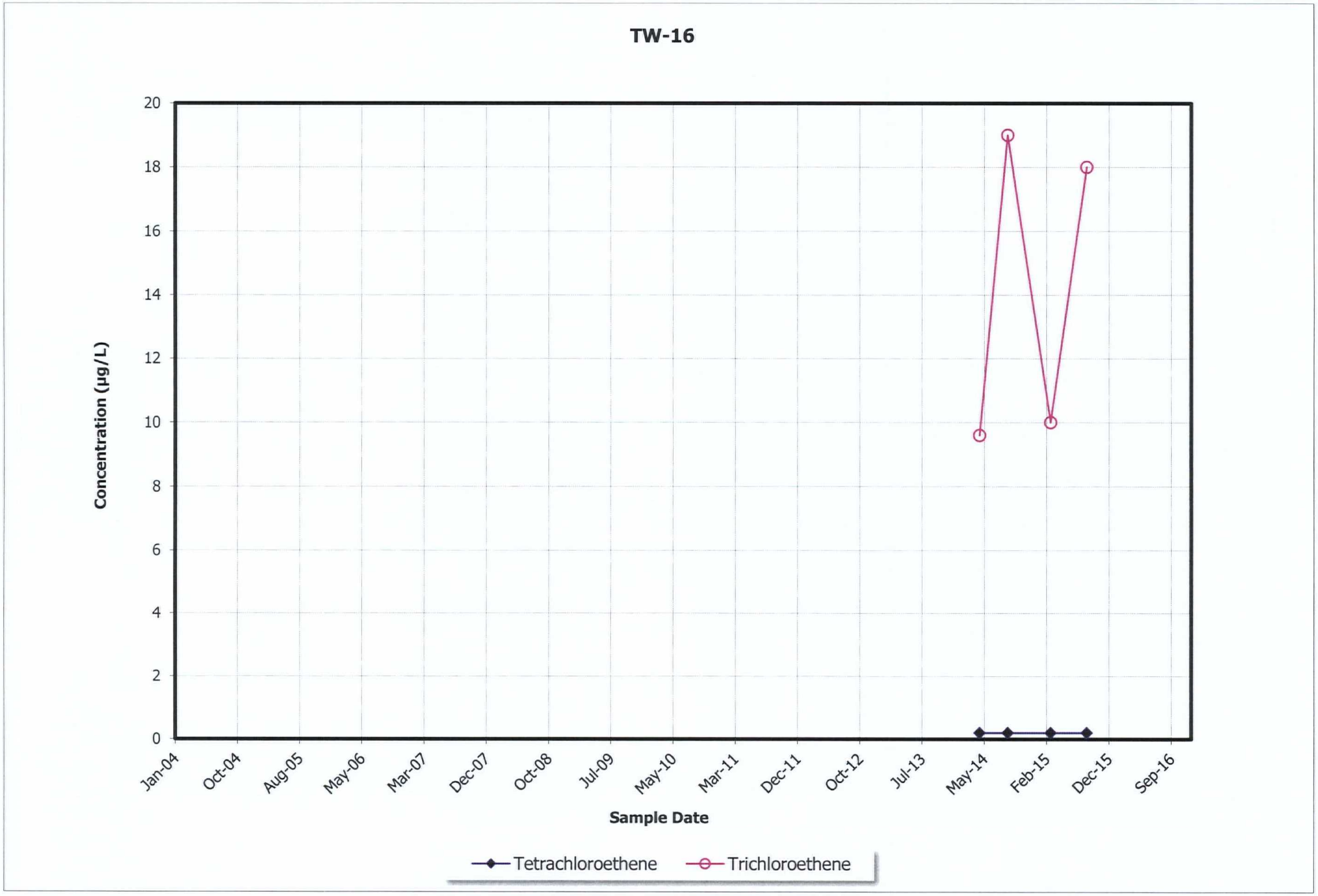

RPZ-730
Concentration (µg/L)
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
Jan-04
Oct-04
Aug-05
May-06
Mar-07
Dec-07
Oct-08
Jul-09
May-10
Mar-11
Dec-11
Oct-12
Jul-13
May-14
Feb-15
Dec-15
Sep-16
Sample Date
Tetrachloroethene
Trichloroethene

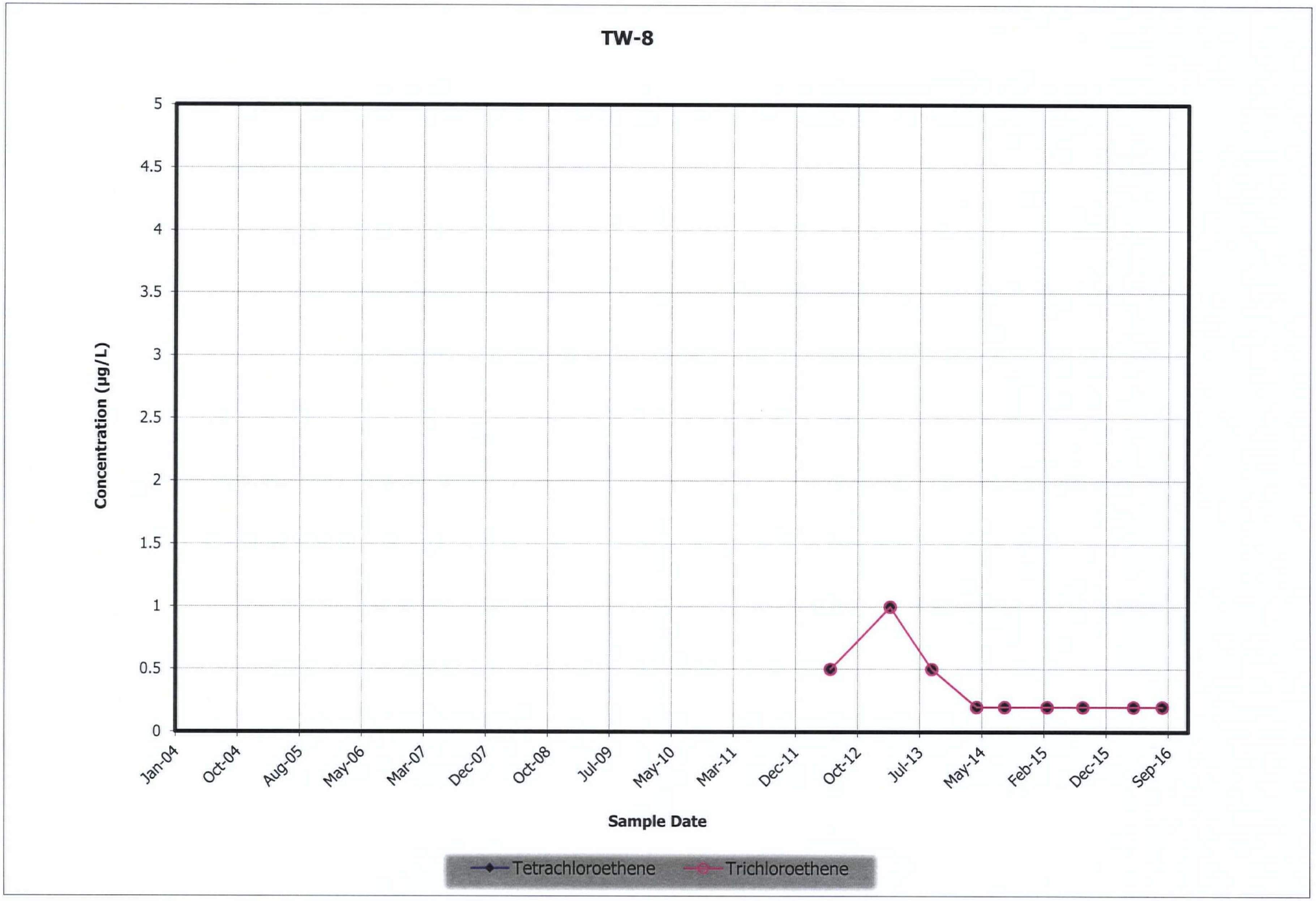


RPZ-731
Concentration (µg/L)
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
Jan-04
Oct-04
Aug-05
May-06
Mar-07
Dec-07
Oct-08
Jul-09
May-10
Mar-11
Dec-11
Oct-12
Jul-13
May-14
Feb-15
Dec-15
Sep-16
Sample Date
Tetrachloroethene
Trichloroethene

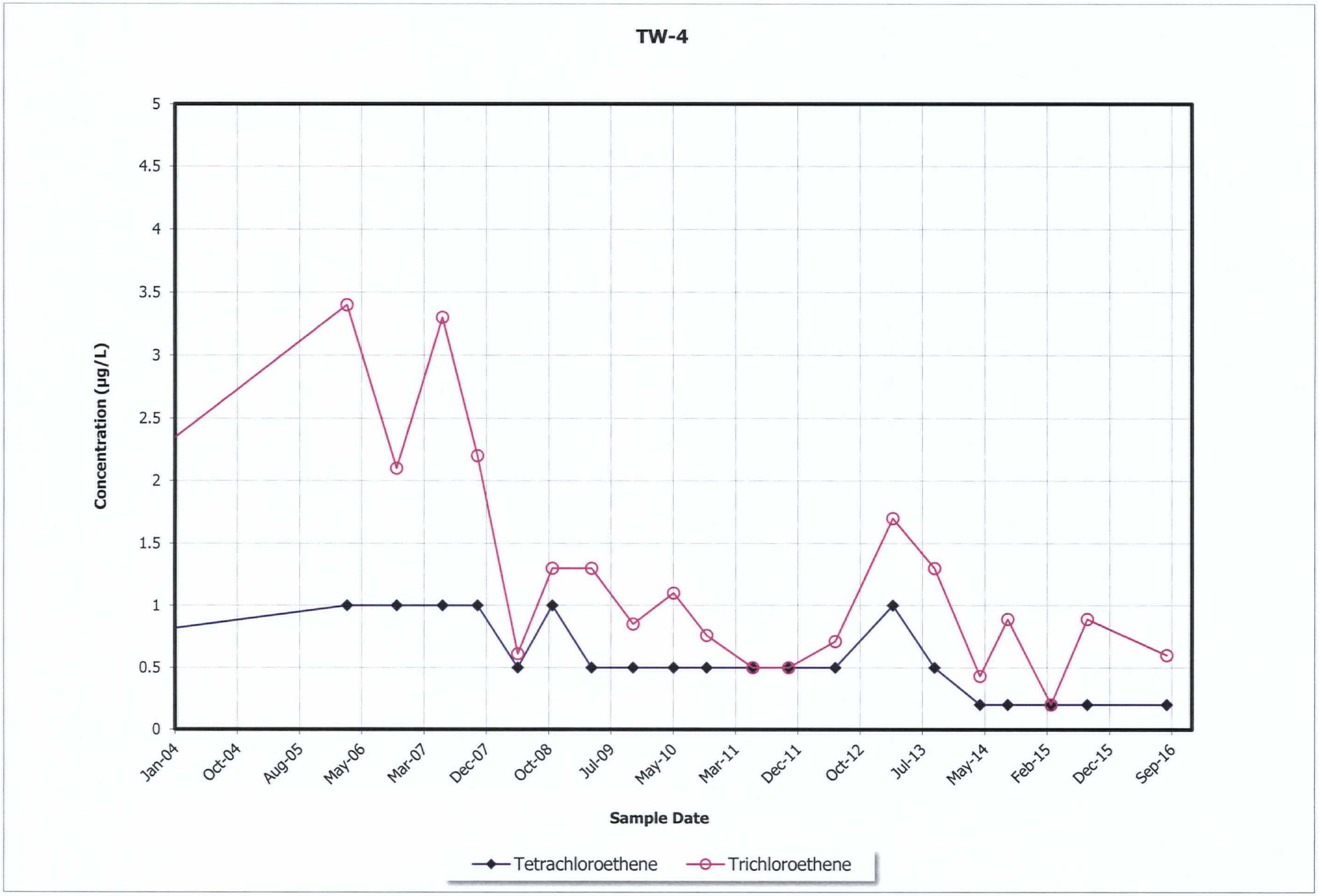


RPZ-732
Concentration (µg/L)
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
Jan-04
Oct-04
Aug-05
May-06
Mar-07
Dec-07
Oct-08
Jul-09
May-10
Mar-11
Dec-11
Oct-12
Jul-13
May-14
Feb-15
Dec-15
Sep-16
Sample Date
Tetrachloroethene
Trichloroethene

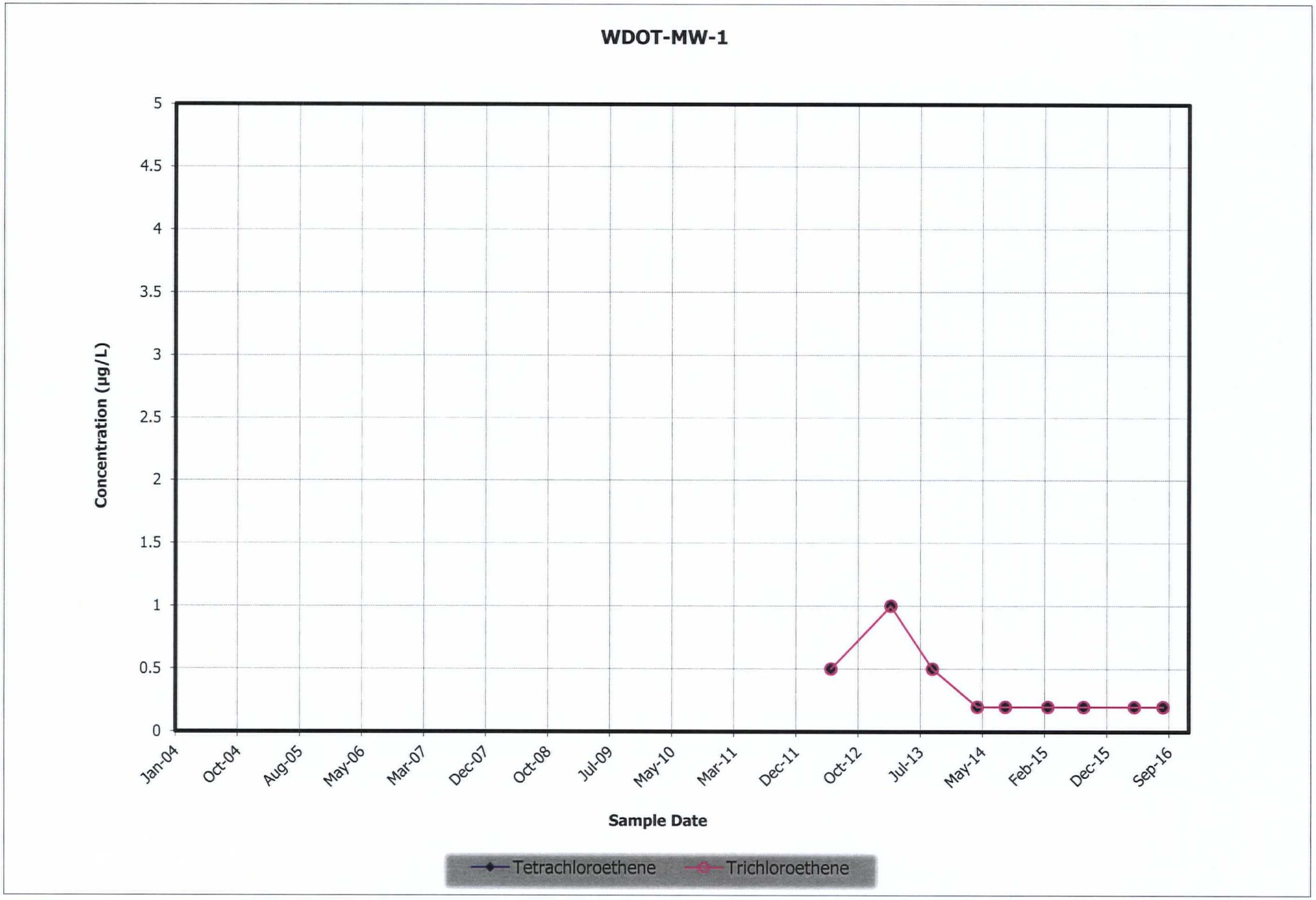

TW-16
Concentration (µg/L)
20
18
16
14
12
10
8
6
4
2
0
Jan-04
Oct-04
Aug-05
May-06
Mar-07
Dec-07
Oct-08
Jul-09
May-10
Mar-11
Dec-11
Oct-12
Jul-13
May-14
Feb-15
Dec-15
Sep-16
Sample Date
Tetrachloroethene
Trichloroethene

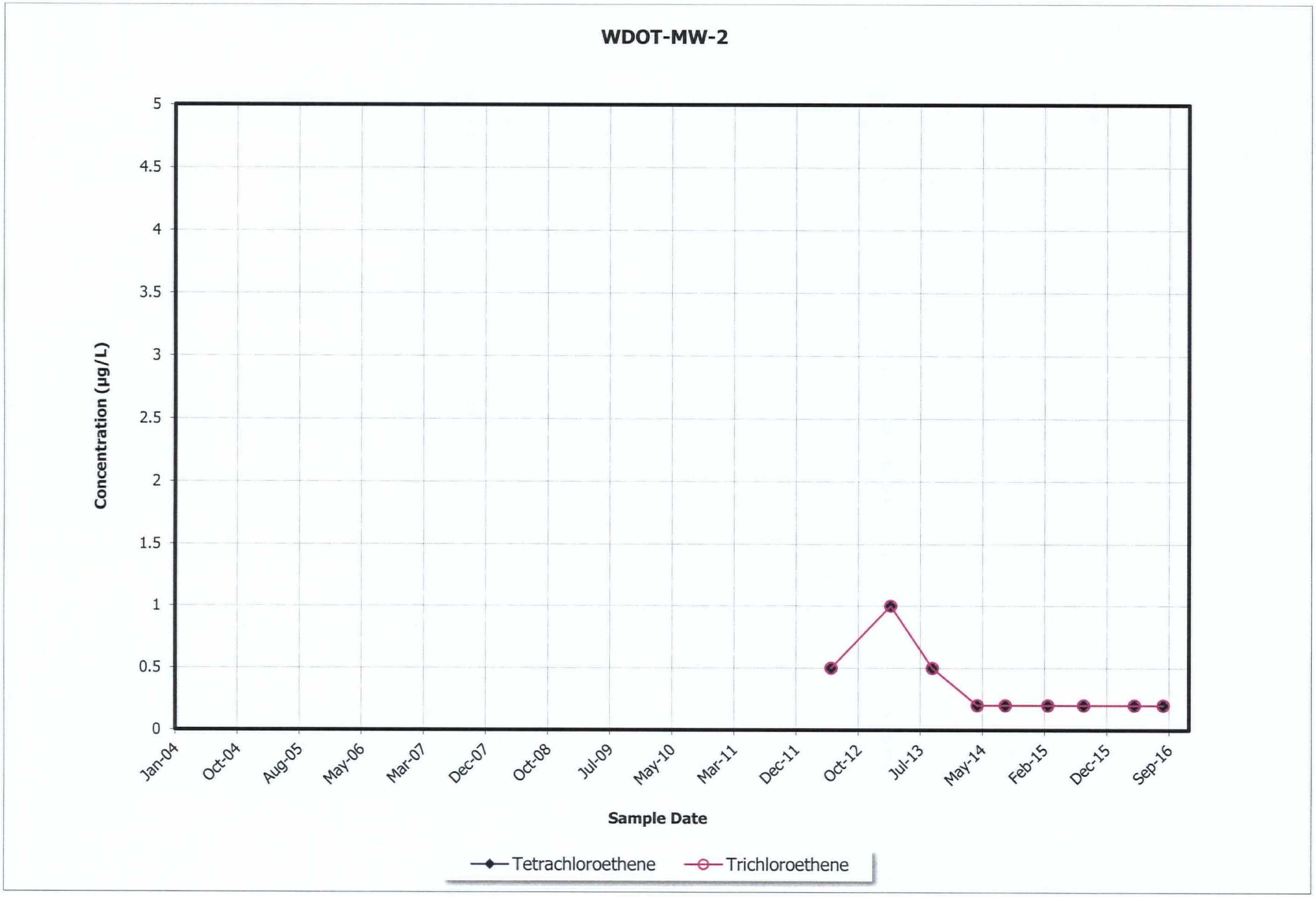


TW-8
Concentration (µg/L)
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
Jan-04
Oct-04
Aug-05
May-06
Mar-07
Dec-07
Oct-08
Jul-09
May-10
Mar-11
Dec-11
Oct-12
Jul-13
May-14
Feb-15
Dec-15
Sep-16
Sample Date
Tetrachloroethene
Trichloroethene



TW-4
Concentration (µg/L)
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
Jan-04
Oct-04
Aug-05
May-06
Mar-07
Dec-07
Oct-08
Jul-09
May-10
Mar-11
Dec-11
Oct-12
Jul-13
May-14
Feb-15
Dec-15
Sep-16
Sample Date
Tetrachloroethene
Trichloroethene


WDOT-MW-1
Concentration (µg/L)
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
Jan-04
Oct-04
Aug-05
May-06
Mar-07
Dec-07
Oct-08
Jul-09
May-10
Mar-11
Dec-11
Oct-12
Jul-13
May-14
Feb-15
Dec-15
Sep-16
Sample Date
Tetrachloroethene
Trichloroethene



WDOT-MW-2
Concentration (µg/L)
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
Jan-04
Oct-04
Aug-05
May-06
Mar-07
Dec-07
Oct-08
Jul-09
May-10
Mar-11
Dec-11
Oct-12
Jul-13
May-14
Feb-15
Dec-15
Sep-16
Sample Date
Tetrachloroethene
Trichloroethene

APPENDIX F
Capture Zone Analysis

APPENDIX F
PRELIMINARY CAPTURE ZONE ANALYSIS

The following section provides a description of the preliminary evaluation for capturing the TCE and PCE plumes utilizing the current remedial technology at the Wellfield. This section is organized to generally follow the EPA guideline for capture zone evaluations (EPA 2008). The guideline suggests six key steps for systematically performing a capture zone evaluation:

1. Review site data, site conceptual model and remedy objectives
2. Define site-specific Target Capture Zone(s)
3. Interpret water levels
4. Perform calculations
5. Evaluate concentration trends
6. Interpret actual capture based on Steps 1-5, compare to Target Capture Zone(s), assess uncertainties and data gaps

Because the current existing chemical analytical data set is not complete and a data gaps investigation is pending, Step 5 was not performed as part of this preliminary capture zone analysis. Steps 1 through 4 and 6 are described below. This capture zone evaluation is considered preliminary to assess the feasibility of using the existing Wellfield remedial technologies to capture, pump and treat all VOC plumes associated with the Site.

Review Site Data, Site Conceptual Model and Remedy Objectives

Previous sections described in detail the extent of the Site data and the current conceptual model. One remedy objective would be to capture each VOC plume by pumping the Wellfield at a rate that would match the groundwater flow rate through the area of each plume and thereby capturing each plume. The impacted groundwater pumped from the wells would be treated utilizing the same remedial technologies that are currently installed and operating for approximately the last 13 years.

It is our understanding through communication with the City that the Wellfield is currently operated on intermittent schedules. The Wellfield is currently operated when the City is in need of supplemental drinking water capacity and is not continuously operated year round.

Plume Delineation

The plume zone targeted for this preliminary capture zone analysis was delineated using the contour of 5 µg/L TCE based on data collected during the Spring 2014 monitoring event, as presented on Figure F-1 as the Target Capture Zone. Figure F-1 shows that the plume extents from the west at MW-U1 at the former WSDOT MTL to the east at TW-16 within the Wellfield. The plume zone depicted on Figure F-1 has also been simplified to include all three VOC plumes from the current and former WSDOT MTL and Southgate Dry Cleaner properties.

Hydrogeologic Information

Two regional aquifer systems are assumed within the Site. The uppermost aquifer system is the Deschutes River Alluvium and the Vashon Drift. This system is considered to be unconfined (Vashon Drift in the uplands) to semi-confined (Deschutes River Alluvium in the valley). The Wellfield wells are completed within the Deschutes River Alluvium at depths ranging from 70 to 110 feet below ground surface. Static water levels within the Wellfield wells are generally less than 10 feet below ground surface.

A uniform thickness of 80 feet for an unconfined aquifer was used in the analysis. Aquifer transmissivities based on the results from pumping tests conducted at the Wellfield range from 23,900 gallons per day per foot (gpd/ft), equivalent to 3,195 feet squared per day (ft^2/day) at TW-17 to 89,000 gpd/ft (11,900 ft^2/day) at Well 8 (PGG, 1992). Thus, the hydraulic conductivity ranged from 300 to 1,100 gpd/ft^2 (40 to 150 feet per day [ft/day]). Scenarios using the low and high transmissivities without spatial variations were analyzed.

The groundwater elevation contours developed based on the Spring 2014 monitoring event were used to evaluate the groundwater flow directions and gradient. Groundwater flow across the study area is generally west to east, with a hydraulic gradient of approximately 0.025 to 0.03 feet per foot (ft/ft).

Currently, only Wellfield wells TW-4, TW-6 and TW-8 are actively pumped by the City. Historical average pumping rates of these existing wells are based on hourly pumping data obtained from the City and are listed in Table F-1. The maximum rate shown on Table F-1 is based on the maximum rate that was sustained for the wells pumping over a period of 4 to 6 hours.

TABLE F-1. CURRENT (2012) AVERAGE AND MAXIMUM SUSTAINED PUMPING RATES (GPM) FOR ACTIVE PALERMO WELLFIELD WELLS AND PROPOSED RATES FOR NEW WELLS, TW-16 AND TW-17

TW-4 (Average/Maximum)	TW-6 (Average/Maximum)	TW-8 (Average/Maximum)	TW-16 (Average/Maximum)	TW-17 Average/Maximum)
84/190	172/390	120/280	–/400	–/350

Two Wellfield wells, TW-16 and TW-17, were drilled and installed in 2012 and 2014, respectively. The recommended pumping rates for TW-16 and TW-17 are 400 and 350 gpm, respectively. Wells TW-2 and TW-5 were decommissioned during 2012 and 2013 (PGG 2013 and 2014). Locations of the Wellfield wells are shown in Figure F-1. Note that TW-6 and TW- 8 are located south and crossgradient to the target plume zone.

Conceptual Model

The preliminary conceptual model is described in Section 2 of the Revised Draft Summary of Existing Information Report. This model was simplified for the capture zone analysis by assuming each plume and the Wellfield are located in one aquifer with a uniform gradient and homogeneous aquifer parameters as described above.

Define Site-Specific Target Capture Zone(s)

The site-specific target capture zone is the TCE-impacted groundwater defined by the 5 µg/L TCE concentration contour as described in the Plume Delineation section described above. The width of the plume that must be captured by pumping the Wellfield is approximately 800 feet. The target capture zone was enlarged to 900 feet to include the zone directly upgradient of the actively pumped Wellfield wells TW-6 and TW-8, which are located south and crossgradient to the plume.

Interpret Water Levels

The water level data and the potentiometric surface maps developed are described above. Seasonal or annual differences in the groundwater elevations were not evaluated for this capture zone analysis, which used an average uniform gradient of 0.028 ft/ft based on the most recent Spring 2014 monitoring event.

Perform Calculations

Two calculations were performed that are based on the capture zone analysis guidelines provided by EPA (2008). The calculations were as follows:

- Estimation of groundwater flow-through in the aquifer through the area of the plumes (capture zone), and
- Estimation of the width of the capture zone that intercept the flow-through.

Flow Rate Calculation

The estimated flow rate calculation provides an estimate for the pumping required to capture a plume based on the rate of groundwater flow through the plume extent. Assumptions for this approach include the following:

- homogeneous, isotropic, confined aquifer of infinite extent
- uniform aquifer thickness
- fully penetrating extraction well(s)
- uniform regional horizontal hydraulic gradient
- steady-state flow
- negligible vertical gradient
- no net recharge, or net recharge is accounted for in regional hydraulic gradient
- other sources of water introduced to aquifer due to extraction

The estimated flow rate under these conditions can be calculated by (EPA 2008):

$$Q = K \cdot b \cdot w \cdot i \cdot f \qquad \text{(E.1)}$$

Or, because $T = K \cdot b$

$$Q = T \cdot w \cdot i \cdot f \qquad \text{(E.2)}$$

Where:

Q = extraction rate (ft^3/day)

K = hydraulic conductivity (ft/day)

b = saturated thickness (ft)

$T = K \cdot b$ transmissivity (ft/day)

w = plume width (ft)

i = regional (i.e., without remedy pumping) hydraulic gradient (ft/ft)

f = "factor", "rule of thumb" is 1.5 to 2.0, intended to account for other contributions to the pumping well such as flux from a river or induced vertical flow from other stratigraphic units are represented by the "factor". In this analysis, three scenarios of the factor value are selected:

- 1.0,
- 1.5, and
- 2.0.

By using Equation E.2, we can ignore the assumption of confined aquifer and uniform aquifer thickness, and use the range of variable transmissivity, *T*, obtained from the pumping tests, representing the variation of both aquifer thickness *b* and hydraulic conductivity, *K*. In this analysis, three scenarios of *T* are selected:

- 23,900 gpd/ft (3,195 ft^2/day), the low transmissivity,
- 50,670 gpd/ft (6,774 ft^2/day) the average of the low and high range of transmissivities, and
- 89,000 gpd/ft (11,898 ft^2/day), the high transmissivity.

For the present study site, the regional hydraulic gradient, *i*, ranges from 0.025 to 0.03 ft/ft. For this preliminary analysis, an average hydraulic gradient value of 0.028 ft/ft was used. Based on Figure F-1, the maximum width, *w*, of the 5 μg/L concentration that defines the target capture zone is approximately 800 feet. This width was increased to 900 feet to include the upgradient area of Wellfield actively pumped wells TW-6 and TW-8. The estimated flow rates, *Q*, through the TCE plume width, for various combinations of parameter values, are given in Table F-2:

TABLE F-2. ESTIMATED FLOW RATE CALCULATION[1]

Factor	Transmissivity (ft^2/day)	Estimated Flow Rate[1] (ft^3/day)	Estimated Flow Rate (gpm)
1	3,195	71,568	372
	6,774	151,738	788
	11,898	266,515	1,384
1.5	3,195	107,352	558
	6,774	227,606	1,182
	11,898	399,773	2,077
2	3,195	143,136	744
	6,774	303,475	1,576
	11,898	533,030	2,769

Note:

[1] Based on estimated plume width of 900 ft and regional hydraulic gradient of 0.028 ft/ft.

Capture Zone Width Calculation

The width of the capture zone was estimated using the following assumptions:

- homogeneous, isotropic, confined aquifer of infinite extent,
- uniform aquifer thickness,
- fully penetrating extraction well(s),
- uniform regional horizontal hydraulic gradient,
- steady-state flow,
- negligible vertical gradient,
- no net recharge, or net recharge is accounted for in regional hydraulic gradient, and
- no other sources of water are introduced to aquifer due to extraction, the width of the capture zone can be obtained by solving the following equation (EPA 2008):

$$x = \frac{-y}{\tan\left(\dfrac{2\pi Ti}{Q}y\right)} \qquad \text{(E.3)}$$

to obtain:

$$X_0 = \frac{-Q}{2\pi Ti}, \qquad \text{(E.4)}$$

$$Y_{max} = \frac{\pm Q}{2Ti}, \qquad \text{(E.5)}$$

and

$$Y_{well} = \frac{\pm Q}{4Ti}. \qquad \text{(E.6)}$$

where,

Q = extraction rate (ft^3/day)

$T = K \cdot b$, transmissivity (ft^2/day)

K = hydraulic conductivity (ft/day)

b = saturated thickness (ft)

i = regional (i.e., pre-remedy-pumping) hydraulic gradient (ft/ft)

X_0 = distance from the well to the downgradient end of the capture zone along the central line of the flow direction (ft)

Y_{max} = maximum capture zone width from the central line of the plume (ft)

Y_{well} = capture zone width at the location of well from the central line of the plume (ft)

Note that this calculation assumes no other sources of water are introduced into the aquifer due to induced flow, such as from surface water or from an adjacent aquifer. When multiple extraction wells are present, this capture zone width calculation is typically applied by assigning the total extraction rate to one "equivalent well". The location of the equivalent well is generally selected visually so it is centrally located with respect to the plume width and/or extraction well locations, and located at the most downgradient position of the actual extraction wells. For this analysis, the equivalent well was located central to the actively pumped extraction wells, TW-4, TW-6 and TW-8. This represents a significant level of simplification for a multi-well extraction system.

For this study, three pumping scenarios were used to estimate the capture zone.

1. Scenario 1 – currently active wells are pumped at their typical average pumping rates based on 2012 hourly pumping rate data obtained from the City. The average rate totals 376 gpm, consisting of 86 gpm from TW-4, 172 gpm from TW-6 and 120 gpm from TW-8. Scenario 1 represents estimated current pumping conditions to show the current capture zone. The "equivalent well" is centrally located relative to TW-4, TW-6 and TW-8.
2. Scenario 2 – currently active wells pumped continuously at their maximum rate. The rate for this scenario is 860 gpm, consisting of 190 gpm from TW-4, 390 gpm from TW-6 and 280 gpm from TW-8. Scenario 2 represents a maximum capture zone using only the currently active wells. The "equivalent well" is located the same as Scenario 1.
3. Scenario 3 – proposed use of TW-4 plus recently constructed TW-16 and TW-17 and pumping all three continuously at their recommended long-term production rates. The rate for this scenario is 940 gpm, consisting of 190 gpm from TW-4, 400 gpm from TW-16 and 350 gpm from TW-17. Scenario 3 represents a maximum capture zone using only the proposed future production wells. Also, the "equivalent well" is centrally located relative to TW-4, TW-16 and TW-17.

Calculations for Y_{well}, Y_{max}, and X_0 for different possible combinations of pumping rate and transmissivity values are presented in Table F-3. The capture zones for all three scenarios using the average transmissivity are shown on Figure F-2. Additionally, the capture zones for Scenario 3 for the high and low range of transmissivities are shown on Figure F-2. The capture zone extents shown on Figure F-2 are in bold on Table F-3.

TABLE F-3. ESTIMATED FLOW RATE CALCULATIONS[1]

Pumping Rate Scenarios (gpm)	Transmissivity (ft^2/day)	X_0 (ft)	Y_{well} (ft)	Capture Zone Width at Wells (ft)	Y_{max} (ft)	Max Capture Zone Width Upgradient (ft)
376	3,195	129	202	405	405	809
	6,774	61	95	191	191	**382**
	11,898	35	54	109	109	217
860	3,195	295	463	925	925	1,851
	6,774	139	218	436	436	**873**
	11,898	79	124	248	248	497
940	3,195	322	506	1,011	1,011	**2,023**
	6,774	152	239	477	477	**954**
	11,898	86	136	272	272	**543**

Compare Actual to Targeted Capture Zones

Even with limited existing information for this preliminary capture zone analysis, it is apparent that the capture zone for the current average pumping rates for the actively pumped wells, Scenario 1, is located almost too far south and is not wide enough to capture the targeted capture zone, the three VOC plumes. This suggests that portions of each plume could be escaping to the east beyond the Wellfield. The likelihood that the Site plumes are fully captured is further reduced because the Wellfield is currently not operated on a continuous schedule.

The capture zone for the maximum pumping rates for the actively pumped wells, Scenario 2, is larger and captures a larger percentage of the targeted capture zone. However, this pumping scenario still does not obtain full capture of the north portion of the Site plumes.

The capture zone for the proposed pumping of Wellfield wells TW-4, TW-16 and TW-17, Scenario 3, is apparently more effective than Scenarios 1 and 2. Using the high-range transmissivity for Scenario 3, the capture zone essentially matches the effectiveness of Scenario 2, with additional capture within the eastern extent of the plume. Using the mid-range transmissivity for Scenario 3, the capture zone appears to capture a significant portion of the plume. The capture zone for the low-range transmissivity of Scenario 3 indicates that there potentially would be nearly full capture of the Site plumes, if the Wellfield is operated on a continuous basis.

Summary and Conclusions

As part of evaluating the nature and extent of TCE at the Site, a preliminary capture zone analysis was performed to assess potential pumping scenarios that could capture the existing Site plumes through existing pumping and treatment techniques. The analysis was conducting using hydrogeologic information available. The key hydrogeologic elements used for the capture zone analysis included a delineation of an area of TCE impact that encompasses the identified three VOC plumes, a groundwater elevation contour map based on the Spring 2014 monitoring event, aquifer parameters based on the analysis done by others of pumping tests conducted on the Wellfield wells, and historical pumping rates obtained from the City.

The preliminary capture zone analysis was conducted using three pumping scenarios for the Wellfield based on current average pumping rates, a maximum rate using currently actively pumped wells, and a maximum pumping rate for a proposed future usage. The results of the analysis indicated that the plume would not be entirely captured at the current usage rates. The analysis did indicate that, depending on the actual transmissivity of the aquifer, the full targeted capture zone could be obtained by pumping TW-4, TW-16 and TW-17 continuously at a maximum rate.

Data Source: Base Map from ESRI Street Map data, 2013.
Hillshade created from Puget Sound Lidar Consortium Lidar (collected 2002).
Projection: NAD 1983 StatePlane Washington South FIPS 4602 Feet

Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.
3. TW-3, TW-16 and TW-17 are installed but not operating.
4) Groundwater chemical analytical data presented was collected in Spring 2014.
5) TCE and PCE contours are estimated using Surfer (Golden Software) 8.0 contouring software using the Natural Neighbor gridding method.

PCE Contours (5 µg/l interval)
TCE Contours (5 µg/l interval)
Monitoring well and identifier
Piezometer and identifier
Groundwater seep and identifier
City production well and identifier
City test well and identifier
Stripper tower and identifier
Former city production well and identifier
Former monitoring well and identifier
Cleanout location and identifier
Approximate PCE/TCE Plume
PCE Target Capture Zones
TCE Target Capture Zones

N W E S

300 0 300
Feet

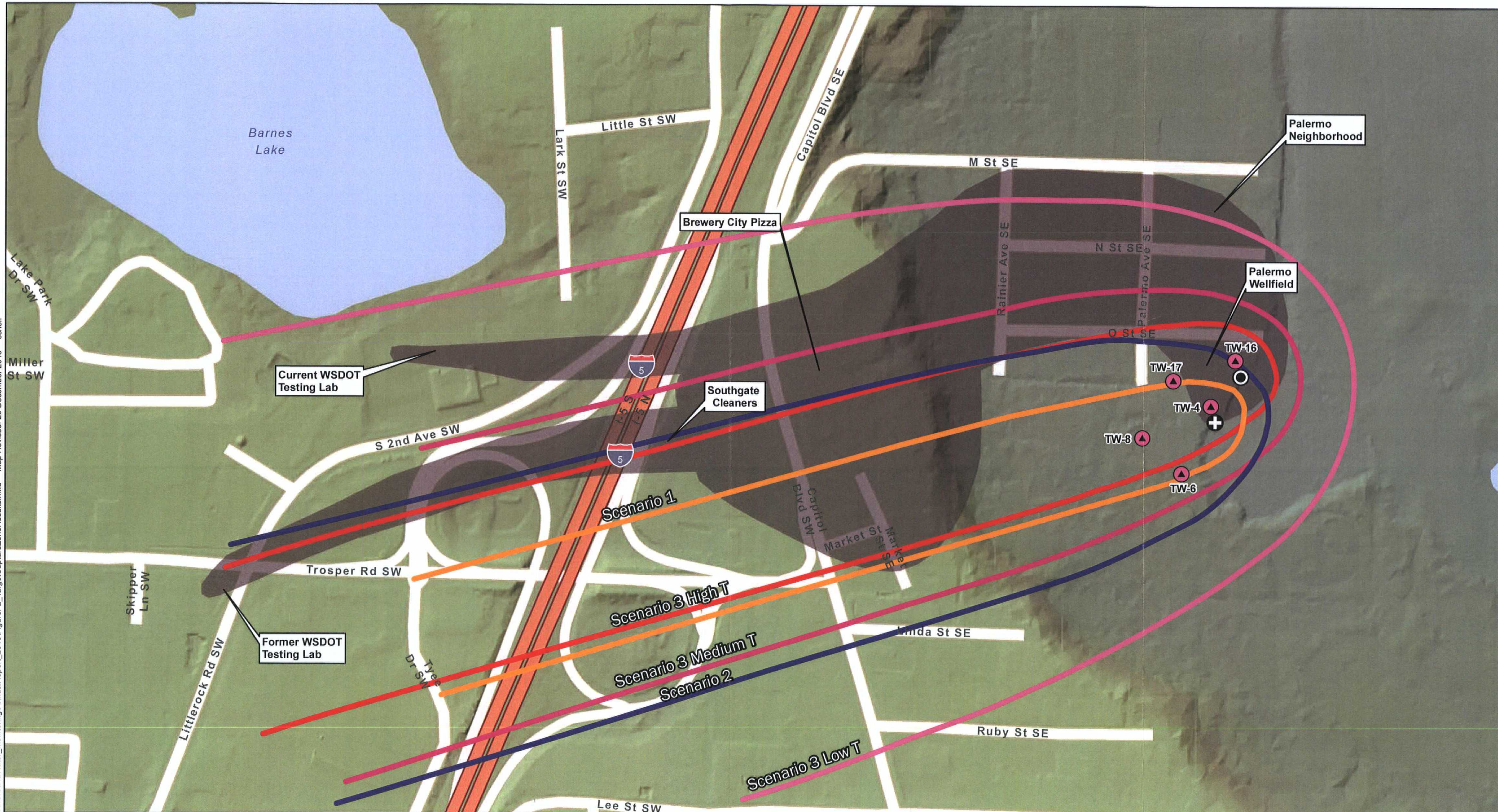
Target Capture Zone

Palermo Wellfield Superfund Site

GEOENGINEERS

Figure F-1

Office: TAC Path: P:\0\0180121\GIS\MXDs\GroundWater_Monitoring\AnnualReport_2015\FigureF1_TargetCaptureZone.mxd Map Revised: 28 December 2015 cchelf



Data Source: Base Map from ESRI Street Map data, 2013.
Hillshade created from Puget Sound Lidar Consortium Lidar (collected 2002).
Projection: NAD 1983 StatePlane Washington South FIPS 4602 Feet

Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.
3. TW-16 and TW-17 are installed but not operating.

City production well and identifier
Approximate PCE/TCE Plume
Equivalent Well for Scenarios 1 and 2
Equivalent Well for Scenario 3

Scenario 1
Scenario 2
Scenario 3 Low T
Scenario 3 Medium T
Scenario 3 High T

N W E S

300 0 300
Feet

Capture Zone Analysis Results

Palermo Wellfield Superfund Site

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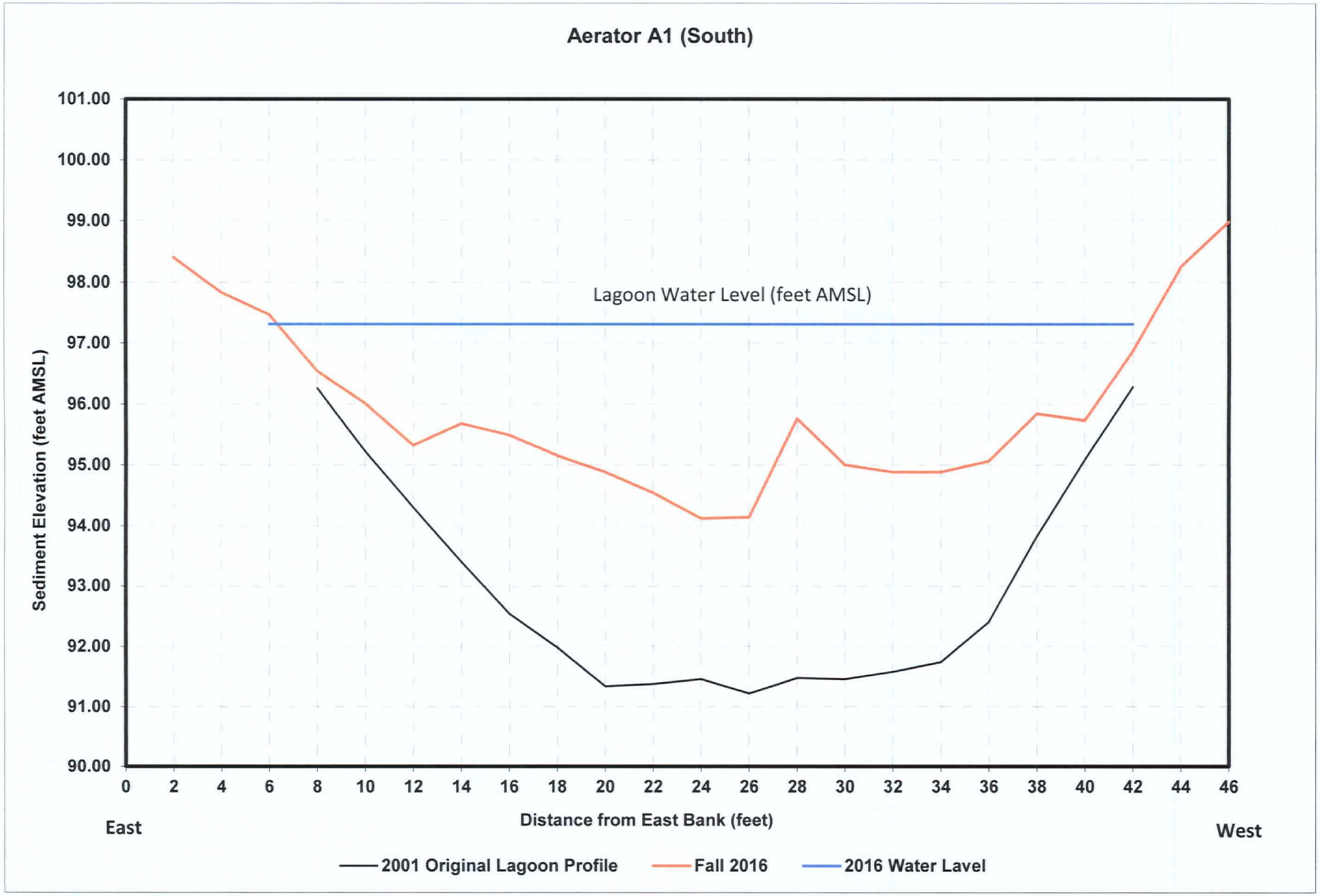
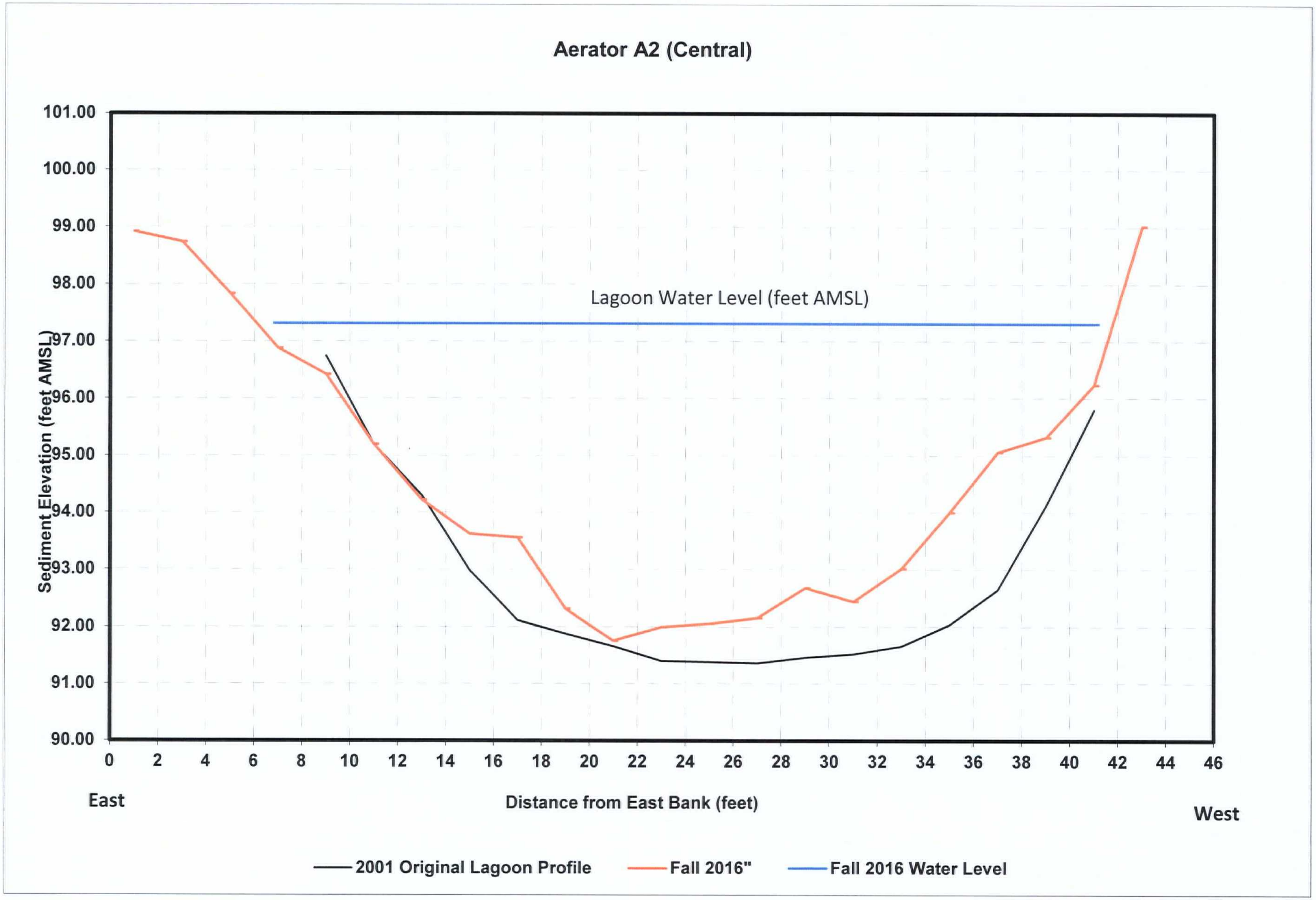
Figure F-2

Office: TAC Path: P:\0\0180121\GIS\MXDs\GroundWater_Monitoring\AnnualReport_2015\FigureF2_TargetCaptureZoneResults.mxd Map Revised: 28 December 2015 cchelf

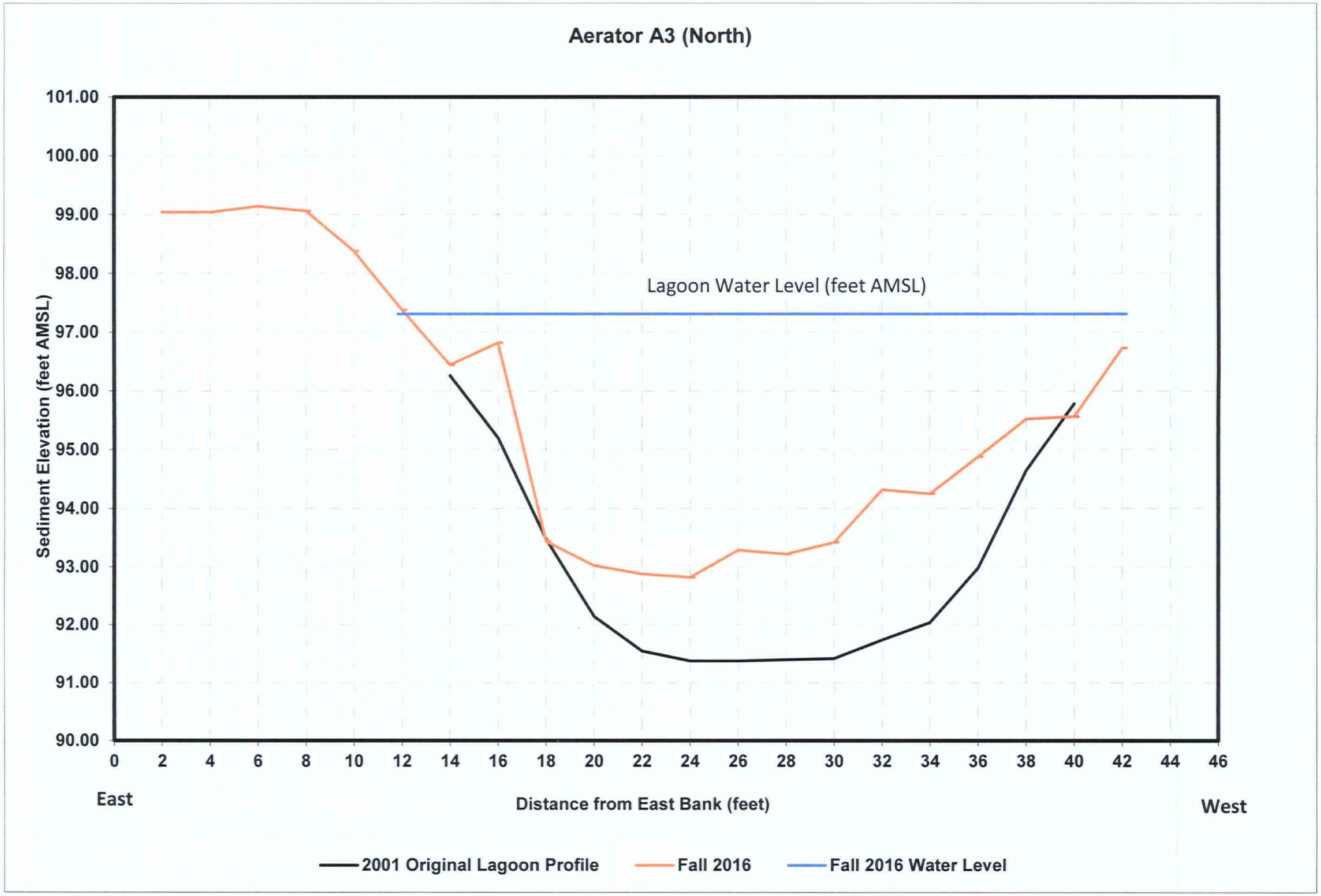
APPENDIX G
Lagoon Transects



Aerator A1 (South)
Lagoon Water Level (feet AMSL)
Sediment Elevation (feet AMSL)
101.00
100.00
99.00
98.00
97.00
96.00
95.00
94.00
93.00
92.00
91.00
90.00
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 46
East
Distance from East Bank (feet)
West
2001 Original Lagoon Profile
Fall 2016
2016 Water Lavel



Aerator A2 (Central)
Lagoon Water Level (feet AMSL)
Sediment Elevation (feet AMSL)
101.00
100.00
99.00
98.00
97.00
96.00
95.00
94.00
93.00
92.00
91.00
90.00
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 46
East
Distance from East Bank (feet)
West
2001 Original Lagoon Profile
Fall 2016"
Fall 2016 Water Level


Aerator A3 (North)
Lagoon Water Level (feet AMSL)
Sediment Elevation (feet AMSL)
101.00
100.00
99.00
98.00
97.00
96.00
95.00
94.00
93.00
92.00
91.00
90.00
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 46
East
Distance from East Bank (feet)
West
2001 Original Lagoon Profile
Fall 2016
Fall 2016 Water Level

APPENDIX H
Report Limitations and Guidelines for Use

APPENDIX H
REPORT LIMITATIONS AND GUIDELINES FOR USE

This appendix provides information to help you manage your risks with respect to the use of this report.

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This report should not be applied for any purpose or project except the one originally contemplated. If important changes are made to the project or property after the date of this report, we recommend that GeoEngineers be given the opportunity to review our interpretations and recommendations, and then we can provide written modifications or confirmation, as appropriate.

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